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THE

INTERNATIONAL ENCYCLOPÆDIA

OF

SURGERY.

VOL. IV.

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THE

INTERNATIONAL ENCYCLOPÆDIA

OF

SURGERY

A SYSTEMATIC TREATISE

ON THE

THEORY AND PRACTICE OF SURGERY

BY

AUTHORS OF VARIOUS NATIONS

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EDITED BY
JOHN ASHHURST, Jr., M.D.
PROFESSOR OF CLINICAL SURGERY IN THE UNIVERSITY OF PENNSYLVANIA

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IN SIX VOLUMES
VOL. IV.

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PREFACE.

THE Fourth Volume of the ENCYCLOPÆDIA continues the discussion of Injuries and Diseases of the Various Tissues, and begins the Surgery of Regions, containing articles on Injuries of Bones, Diseases of Joints, Excisions and Resections, Tumors, Injuries of the Back, and Malformations and Diseases of the Spine. The article on Diseases of the Bones, which it was intended to include in this volume, is postponed to a later portion of the work, Prof. OLLIER, of Lyons, who has undertaken its preparation, having found it impossible to complete the task as early as had been expected, and the Editor thinking it better to change the arrangement of material in the present volume, rather than to delay its issue.

The elaborate article herewith presented on Injuries of the Back, possesses the melancholy interest of being a posthumous contribution from the pen of the lamented LIDELL, who died almost as the last proof-sheets of his work were being corrected; it had been his intention to add a brief supplement, referring to several cases of spinal injury recorded in the Third Surgical Volume of the Medical and Surgical History of the War of the Rebellion, and, had he been spared to accomplish his purpose, he would doubtless also have taken some notice of the recently published views of Mr. H. W. Page as to the so-called "railway-injuries of the spine," views which differ in certain particulars from those which Dr. LIDELL has advocated. A few memoranda for the proposed supplement, left by the distinguished author, were placed by his family in the Editor's hands, but, after careful consideration, it has seemed best to leave Dr. LIDELL'S article as he had completed it—a finished whole—and not to risk marring its symmetry by patching it with the work of another.

Of the plates which accompany this volume, those illustrating the Microscopic Appearances of Tumors are furnished by Mr. BUTLIN. The remainder are from patients under the Editor's care in the Hospital of the University of Pennsylvania, with the exception of that representing a Sarcoma of the Humerus and Scapula, which is from a patient seen in consultation with Drs. Massey and Price, of West Chester.

JOHN ASHHURST, JR.

PHILADELPHIA,
2000 WEST DELANCEY PLACE,
November, 1883.

THE INTERNATIONAL ENCYCLOPÆDIA OF SURGERY.

ARTICLES CONTAINED IN THE FOURTH VOLUME.

Injuries of Bones. By John H. Packard, M.D., Surgeon to the Episcopal Hospital and to St. Joseph's Hospital, Philadelphia. Page 1.

Diseases of the Joints. By Richard Barwell, F.R.C.S., Surgeon to Charing-Cross Hospital, London. Page 261.

Excisions and Resections. By John Ashhurst, Jr., M.D., Professor of Clinical Surgery in the University of Pennsylvania, Philadelphia. Page 439.

Excision of the Knee-Joint. By George E. Fenwick, M.D., C.M., Professor of Surgery in McGill University; Surgeon to the Montreal General Hospital. Page 535.

Tumors. By Henry Trentham Butlin, F.R.C.S., Assistant Surgeon to, and Demonstrator of Surgery at, St. Bartholomew's Hospital, London. Page 543.

Injuries of the Back, including those of the Spinal Column, Spinal Membranes, and Spinal Cord. By John A. Lidell, A.M., M.D., Late Surgeon to Bellevue Hospital, New York; also Late Surgeon U. S. Volunteers in charge of Stanton U. S. Army General Hospital, Inspector of the Medical and Hospital Department of the Army of the Potomac, etc. Page 667.

Malformations and Diseases of the Spine. By Frederick Treves, F.R.C.S., Assistant Surgeon to, and Senior Demonstrator of Surgery at, the London Hospital. Page 891.

ALPHABETICAL LIST OF AUTHORS.

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RICHARD BARWELL,
HENRY TRENTHAM BUTLIN,
GEORGE E. FENWICK,
JOHN A. LIDELL,
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By

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By

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EXCISION OF THE KNEE-JOINT.

By

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By

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INJURIES OF THE BACK,

INCLUDING THOSE OF THE SPINAL COLUMN, SPINAL MEMBRANES, AND SPINAL CORD.

BY

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INCLUDING THOSE OF THE SPINAL COLUMN, SPINAL MEMBRANES, AND SPINAL CORD.

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By

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THE INTERNATIONAL ENCYCLOPÆDIA OF SURGERY.

INJURIES OF BONES.

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FRACTURES.

THE main function of the bony skeleton and of its accessory cartilages is passively mechanical.[1] They constitute a framework for the suspension and protection of the viscera, and for the utilization of muscular force in the performance of all voluntary movements, as well as in the automatic function of breathing. By their construction and arrangement, the bones and cartilages are adapted to bear all the strain put upon them in the ordinary course of life, but they are sometimes subjected to violence beyond their power of resistance, and fracture or breakage is the result.

A very large proportion of the cases which present themselves to the surgeon, whether in hospital or in private practice, are those of broken bones; and for this reason, as well as on account of the gravity of the conditions often involved, and the probable permanency of any untoward result, it is a matter of much moment that this subject should be thoroughly studied, and in the most practical manner. An accurate acquaintance with normal anatomy is essential; and no opportunity of examining fractures, whether in the living body or in the dead, in recent or in old specimens, should be neglected. Clinical experience, such as is gained in hospitals, is of great value, as are also mechanical ability and dexterity in the adaptation and application of apparatus. The habit of gentleness of touch, and of firm and skilful handling of injured parts, should be sedulously cultivated.

It may be said further, that out of no other class of cases have arisen so many suits for malpractice. The reason of this is not difficult to perceive.

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[1] Rindfleisch has recently pointed out the important part taken by the *marrow* of bones in the formation of the red corpuscles of the blood; but this has not yet been shown to have any surgical interest.

Lameness in the lower extremity, or disability in the upper, will fix the attention of the patient, and attract the notice of others. Sometimes the surgeon may have indiscreetly promised, during the treatment, perfect recovery, or may have overlooked restlessness, or even disobedience, on the part of the patient. Sometimes the latter is struck with the more favorable result of other cases as compared with his own; and sometimes, unfortunately, the idea of bringing suit is suggested to him by meddling friends or pettifogging lawyers. But whatever may be the origin of such proceedings, they are always annoying and vexatious, often expensive, and generally injurious to the surgeon, even if the verdict should be in his favor. Hence, it is highly desirable that they should be avoided, as far as possible, by the exercise of the utmost skill, care, and discretion, in the management of the injuries now in question.

There are some fractures which are serious by reason of the danger of loss or impairment of the function of the bone itself, and in which, therefore, the main object of the surgeon's treatment must be the most perfect possible restoration of the normal form and relations of the bone. Such are those of the humerus, the femur, and the bones of the leg or forearm.

Others derive their gravity chiefly from the risk of involvement of contained viscera; such are those of the skull, vertebræ,[1] ribs, and pelvis. Even in fractures of the long bones, there are sometimes such injuries inflicted upon the neighboring soft parts, bloodvessels, or nerves, or both, as to produce the gravest results. Cases of this kind will be noted in connection with fractures, especially, of the clavicle, femur, and bones of the leg.

Every bone in the body is liable to fracture; but, as will further appear, some bones are much more exposed, and much more frequently broken, than others. And just as the normal function of these organs is carried on in exact accordance with the laws of mechanics, so in their fractures the working of the same laws may be traced. In the general discussion of the whole subject, fractures of the long bones will be kept in view, not only because they are more frequent, but because they afford the best and most convenient illustrations of the phenomena presented.

The points for study in regard to these injuries are: their causes; the mechanism of their production; their varieties; the phenomena and symptoms attending them; their diagnosis; their consequences; their complications; the mode of their repair and deficiencies in this process; their prognosis; and the principles of their treatment. All these topics will be first taken up in a general way, and they will subsequently be considered in reference to the several bones.

Causes of Fracture.

Fractures are always caused by force, and by adequate force; although under certain circumstances it may and does seem as if the bones gave way, as it were, of themselves. Hence the term "spontaneous" has been used; but, as will be hereafter shown, it is not strictly correct.

The causes of fracture may be divided into *immediate* and *predisposing.* Under the former head are embraced the various forms of violence under which bones give way, while under the latter belong all conditions, whether of the body at large, of the skeleton, or of the individual bones, which expose the latter to fracturing forces, or make them more ready to yield.

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[1] Fractures of the skull and of the vertebræ are so generally attended with lesions of the great nerve-centres, and these lesions give rise to questions of such magnitude and such special interest, that these subjects will be hereafter dealt with in separate articles.

IMMEDIATE CAUSES.—It would be vain to try to enumerate all the special forms of violence by which, in the complicated conditions of human life, bones are broken. But they may be classified under four general heads: direct and indirect violence, muscular action, and avulsion.

Direct violence is that which is inflicted upon the bone at the point where the fracture occurs; such as a blow with a stick or a stone, the passage of a wheel over a limb, or the fall of a heavy body upon it. Here the momentum of the impinging mass is expended in overcoming the resistance of a portion of the bony tissue.

Indirect violence is that which is transmitted through some length of the bone, which becomes an overtaxed lever; as, for example, when a man falls from a height, alighting upon his feet, and the femur gives way at some portion of its shaft. Here the resistance of the ground, acting through the foot and leg, fixes the lower end of the femur, while the momentum of the body continues to drive the upper end of this bone downward; and the natural curve of the shaft is increased until its texture gives way.

As will presently be further shown, there is often also an element of twisting added to the leverage.

Muscular action, when it causes fracture, must either be extremely violent and sudden, as in cases of convulsion or very powerful effort, or the bone must be taken at a disadvantage, as will be further explained in speaking of the mechanism of fractures generally, as well as of those of special bones.

Fractures by *avulsion* are those in which a small fragment of bone is torn away by the stress put upon ligamentous structures attached to it. They are more generally known at present as "sprain-fractures," and the observations to be made concerning them will be found in connection with fractures close to the joints, especially of the knee and ankle.

So many illustrations of the foregoing statements will be given in discussing the mechanism of fractures, as well as in describing these injuries as affecting special bones, that I shall dwell no further upon them here; only saying that in very many cases the agency of indirect force is greatly aided by the occurrence of muscular contraction at the moment of its application.

PREDISPOSING CAUSES.—Among the *general* diseases which have been thus ranked by authors, there are some which admit of much doubt. Thus, in regard to *gout*, *rheumatism*, and *scurvy*, there seems to be no evidence that they render the bones more fragile; although they may possibly, by crippling or weakening the limbs, make their victims clumsy, and less able to avoid falls or escape violence. Yet it must be remembered that persons so diseased are obliged to take care of themselves, and to abstain from the active pursuits which would involve exposure to the usual fracturing forces.

Scrofula has been placed by some writers in this category, but there is really no evidence that it belongs here. Its subjects are sometimes ill-nourished and feeble, and very probably their bones, like their tissues generally, are weak in texture. But many of the scrofulous are strong and active, and in these there is no sign of fragility of the bones unless they are actually affected with caries, and not always then. After healing has taken place, the osseous tissue seems to be condensed and peculiarly firm, although the constitutional disorder may be still progressing.

Syphilis has been assigned by some as a cause of fragility of the bones, and many cases are on record in support of their views. Berkeley Hill[1] mentions a case in which a child six weeks old, already affected with snuffles and pemphigus, sustained a fracture of the left humerus by the mother "catching the arm in a hole in the towel with which the child was being dried. When the child was examined, the right clavicle was bent and thickened with callus near its middle, where it had been broken at some time unknown to its mother. The fractured bone united in the usual manner." He also speaks of fractures occurring in syphilitic children during their birth, quoting a case recorded by Porak;[1] and says that "in adults the bones occasionally give way under a trifling strain." Gross[2] mentions the case of a man aged 31, whose humerus gave way as he threw a small chip at a dog. He had had syphilis seven years before, and was at the time subject to nocturnal pains in the arm and forearm. Prof. Chiari, of Prague,[3] maintains that the occurrence of "gummous osteomyelitis," or central gummata, in the medullary structure of the long bones, is not rare, and may afford an explanation of these cases of apparently spontaneous fracture. But when we consider, first, the immense number of syphilitic patients constantly under observation, and the rarity of fractures among them, and secondly, the fact that in many persons presumably free from any such taint the bones give way to seemingly inadequate force, it must be admitted that the basis of the theory that syphilis weakens the bony structures is but a slight one. Only a very few instances have been reported in which fractures have taken place at the seat of the so-called tertiary lesions.[4]

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[1] Syphilis and Local Contagious Disorders, 2d ed. London, 1881.

Cancer is another malady which has long had the reputation of affecting the strength of the osseous system. But here also the fact would seem to be that it is only when local manifestations of the constitutional taint occur in the bones, that these organs show any unusual fragility. At least we may say, as in the case of syphilis, that in view of the great number of cases of cancer constantly under the eyes of the profession, it is strange that fractures without local deposit should so seldom occur, if the pathological change in the bones were really an element in the natural history of the disease.

It is otherwise with regard to certain *disorders of the nervous system*, which are attended with such degeneration of the nerve centres as to affect the trophic innervation of many organs, and especially of the skeleton. Perhaps the bones betray this influence the more readily by reason of their low grade of organic activity. Attention seems to have been first drawn to this subject by Davey,[5] who reported the case of an insane person, an autopsy upon whom disclosed six so-called "spontaneous" fractures—three in the two femora, and three in the humerus, radius, and clavicle respectively. At a later period, the frequency with which fractures of the ribs were found in patients dying in lunatic asylums, attracted notice; it was thought that these lesions were due to maltreatment by attendants, until the publication of numerous observations by Pedlar,[6] Hearder,[7] and others, showed softening of the bones to be one of the elements of a tabetic condition apt to occur in the later stages of insanity. The bones of two insane persons dying with fractured ribs, are said by Ormerod[8] to have been dark, wet, greasy, easily decomposed, enlarged, and with thin outer walls; under the microscope they showed much fatty matter, and a granular condition like ossifying cartilage.

According to T. L. Rogers,[9] the organic constituents of the bones in a similar case were in larger amount, and the proportion of lime to phosphoric acid less, than normal; the bones resembling those of the fœtus. Moore[1] placed upon record a case of "osteo-malacia" in a woman, aged 70, the subject of acute mania, who had had at different times four fractures, and who died soon after the fourth. He does not appear, however, to have recognized this "breaking down of the bone-tissue" as dependent upon the disease of the central nervous system.

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[1] Gaz. Méd. de Paris, 1877, p. 538.

[2] System of Surgery, vol. i. p. 898, 6th ed., 1882.

[3] Phila. Med. Times, Feb. 10, 1883, from Vierteljahrsschr. für Dermatologie und Syphilis.

[4] Arnott, London Med. Gazette, June 5, 1840.

[5] Medical Times, Dec. 24, 1842.

[6] West Riding Lunatic Asylum Report, 1871.

[7] Journal of Mental Science, Jan. 1871.

[8] St. Bartholomew's Hospital Reports, vol. vi. 1870.

[9] Liverpool Med. and Surg. Reports, vol. iv. 1870.

In 1867 I made an autopsy in the case of the late Dr. Pennock,[2] who had been long a paralytic; the bones were all so soft as to be easily cut with a knife, and presented much the same appearance as those above mentioned, although no fracture had taken place.

Dr. Weir Mitchell, in 1873,[3] in an article on "Rest in Locomotor Ataxia," said: "It naturally occurs to ask why so many ataxics have chanced to break limbs? and as to this I should answer, first, that no people are so awkward or fall so much; and, next, that in some of the cases it seemed to me that the habitual abruptness of the muscular acts had a share in the calamity, and that I have suspected, what has not yet been proved, that the bones in ataxics may suffer some impairment of their nutrition, and hence of their strength." Charcot[4] reported a very remarkable case, in which several fractures occurred in the person of an ataxic woman; and referred, with assent, to the suggestion of Mitchell, just quoted. Further observations were communicated to the Pathological Society of London, in 1880, by Buzzard,[5] and the subject was discussed by Hutchinson and others.

A lady, about 60 years of age, was under my care in 1879, who had long been paraplegic, and who, by catching her foot against a cushion as she was lifted into a carriage, sustained a fracture of both bones of the right leg; just about a year previously she had broken the other leg from an equally slight cause. A very similar case, in a man of 65, was placed on record by Mr. Busk.[6]

Professor Bruns, of Tübingen, has published a very interesting paper,[7] based upon the case of an ataxic woman, æt. 57, who had sustained fractures, at different times, of both forearms; the right without known cause, the left in lifting a plate. He gives a long list of references to articles, by various authors, bearing upon the subject, and defines the change which occurs in the bones as an eccentric atrophy, with rarefaction of the compact substance, and filling of the widened marrow-spaces with fat. Ross,[8] speaking of tropho-neuroses, says:—

"Spontaneous fractures have attracted the attention of surgeons from a remote period, but these accidents were attributed to the influence of certain diatheses, such as gout, rheumatism, scrofula, and cancer. Larrey drew special attention to the fact that a certain form of paralysis of the lower extremities was associated with a strong predisposition to fractures of their bones. In the record of this case, however, it is mentioned that the so-called paralytic symptoms were associated with amaurosis and great exaltation of the sensibility of the lower extremities, which renders it almost certain that the symptoms were not due to paralysis, but to ataxia. In 1873, Weir Mitchell drew attention to the frequency of spontaneous fractures in locomotor ataxia, and suggested that during the progress of the disease the bones had undergone nutritive changes which greatly diminished their resistance. This subject was subsequently investigated by Charcot and his followers, with their usual thoroughness and success. The period of fracture is usually preceded by two or three paroxysms of lancinating pain of unusual severity; and at the same time the limb is found swollen, and with all the symptoms of osteo-periostitis, and fracture occurs on the slightest movement of the limb, or in the entire absence of any movement or other external cause. The femur is more frequently fractured than any other bone, the seat of fracture being frequently the neck of the former; but the bones of the leg, arm, forearm, and, indeed, almost every bone of the limb and trunk, have been found fractured, including the vertebral column. Multiple fractures in the same patient are by no means uncommon, and in a case published by Charcot, the patient, towards the close of life, could scarcely move in bed without fracturing some one or other of the few bones which had not been already fractured. Damaschino has drawn attention to the fact that the spontaneous fractures of ataxics reunite very readily and rapidly, with an enormous formation of callus."

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[1] St. George's Hospital Reports, 1871–2.

[2] See American Journal of the Medical Sciences, July, 1868.

[3] Ibid., July, 1873.

[4] Arch. de Physiologie, Janvier, 1874.

[5] Brit. Med. Journal, Feb. 14, 1880. The reader may refer with advantage to another article by Buzzard, "On the Affection of the Bones and Joints in Locomotor Ataxy," in the British Medical Journal for March 5, 1881.

[6] London Medical Gazette, April 10, 1840.

[7] Spontan-fracturen bei Tabes. Berl. klin. Wochenschr., March 13, 1882.

[8] Treatise on Diseases of the Nervous System, 1881, vol. i. p. 224.

Dr. Debove, in a communication to the Paris Hospital Society, observed that in his practice at the Bicêtre, he had frequent occasion to see fractures in the subjects of hemiplegia, these fractures always occurring on the hemiplegic side, there being every reason to believe that changes took place in such cases in the osseous tissue, rendering it more fragile. In one case of chronic hemiplegia he found that not only the fractured bone itself, but all the bones on the same side, had undergone such change. They were less heavy than on the sound side, the medullary canal was larger, and the substance of the diaphysis was less compact. Examined histologically, the Haversian canals were found much dilated, and the bone porous. Chemical examination also showed that the diaphysis contained a larger quantity of fat. These fractures usually consolidated rapidly, the callus being somewhat voluminous.[1]

It would seem clear, from the foregoing, that there is in many forms of central nervous disease, including hemiplegia, paraplegia, locomotor ataxia, general paralysis of the insane, and perhaps other allied conditions, a state of defective nutrition brought about in the bones, whereby they are rendered either softer or more brittle, and which causes them to yield very readily to slight fracturing forces. Very possibly, further study of the subject may throw additional light upon the whole series of changes; but the statement just made is an embodiment of what is now known with regard to it.

Rachitis, or rickets, a disease supposed by most writers to be almost wholly unknown in this country,[2] has been not unfrequently observed as a predisposing cause of fracture by British and Continental surgeons. It affects children chiefly, and is manifested by softening and distortion of the bones, with enlargement of their articular extremities. It may be that such cases often occur among the lower classes of our negroes, the parents being ill-fed, poorly clothed, and often strumous or syphilitic; and that the deformed limbs so commonly seen in that race among us, are the traces of congenital rickets.

Hamilton[3] mentions a case seen by him in 1853, in which, in an infant four days old, born of a healthy mother and at full time, "nearly all of the long bones were separated and movable at their epiphyses, the motion being generally accompanied with a distinct crepitus. The bones were also much enlarged in their circumference; the bones of the forearm and the femur were greatly curved; the fontanelles were unusually open; and the clavicles were entirely wanting. The child was of full size, but looked feeble. It died in a condition of marasmus six months after birth; at which time some degree of union had taken place at several of the points of separation, the limbs having been supported constantly with pasteboard splints and rollers."

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[1] Medical Times and Gazette, Oct. 29, 1881; from Gaz. des Hôpitaux, 20 Oct. 1881.

[2] See the article on Rachitis, by Dr. J. Lewis Smith, Vol. I. p. 251. In the American Journal of the Medical Sciences for January and April, 1872, the reader may find an admirable discussion of this disease by the late Dr. John S. Parry, who says he "has been irresistibly forced to the conclusion that rachitis is scarcely less frequent in Philadelphia than it is in the large cities of Great Britain and the continent of Europe, and that it should occupy just as important a place in our mortuary lists as Hillier conceives that it should in those of the registrar-general of England."

[3] Practical Treatise on Fractures and Dislocations, 6th ed., 1880, p. 33.

A case was reported by Collins to the Manchester Medical Society,[1] in which a condition allied to rickets seemed to have been brought about in a child by the deficiency of casein in the mother's milk. The child was born January 2, 1882; when first seen, January 13, the left femur presented every appearance of having been fractured and recently united. On the 30th, the left humerus was found to be broken; on February 20, the right humerus, and on February 24, the right femur. Each fracture was at the centre of the shaft, and there was in no instance any evidence of violence or injury. There was no history of syphilis; the child's bones were curved. All the fractures united readily.

As illustrative of the more pronounced cases of rickets, I may quote from Malgaigne[2] a case recorded by Jacquemille:—

> The patient was "born of healthy parents, but affected from his first year with general rachitis, which had flattened his ribs, distorted his spine, and curved all the long bones except the humerus. He could not walk till five years old, and remained always excessively small and feeble. Toward the age of twelve, in climbing a wood-pile, he fell and broke the right arm at the middle. The fracture was simple, and united perfectly. At fifteen, trying to get up behind a carriage, he lost his footing, and fractured both thighs; which uniting with deformity, he was permanently crippled on the right side. At seventeen, he broke the left arm. At twenty-eight, he broke the left thigh, at a different point from before. Finally, at thirty-two, he again broke the right thigh, likewise at a new point. The case was now lost sight of."

Mr. R. Barwell[3] lately showed to the Pathological Society of London—

> A girl, aged 17, but apparently very much younger, who presented a most extraordinary series of deformities. Her family history threw no light on her condition, which was not congenital. In her mental development she was juvenile rather than weak, and she had not reached puberty. Very few of her bones were free from deformity. Both humeri were much bent, but especially the right; so that, on that side, whereas the humerus measured seven inches and a half, the length of the arm from acromion to olecranon was only four inches and a quarter; again, the right tibia measured nine inches and a half, but the length of leg was only four inches and a half. This was owing to the bone, at about the lower fourth, being bent back on itself, so that it ran upwards and parallel to the rest of the bone. The left olecranon process was greatly lengthened, and placed at an obtuse angle to the shaft of the bone. . . . . The bones, a few years ago, had been remarkably brittle, and still remained so, but to a less degree. Between the ages of 9 and 13, she had broken her arms four times, and her lower limbs on several occasions. There was no bending of the ribs, nor any enlargement of the epiphyses.

Mr. Barwell did not think that the case could be classed either with rickets or with osteo-malacia. He had had under his care, some years ago, a boy who presented similar deformities, but less marked, and he had endeavored to straighten the femur. On cutting down to it, however, he found that on the slightest force the chisel sank through the whole structure of the bone, and about five fluidounces of liquid fat flowed out. Both of these patients suffered from pain referred to the convex side of the distorted bone. He thought that there was hypertrophy of the medulla at the expense of the bone proper.

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[1] Brit. Med. Journ., May 13, 1882.

[2] Traité des Fractures et des Luxations, tome i. p. 20; Translation, p. 33.

[3] Brit. Med. Journ., Dec. 9, 1882.

J. Cloquet[1] says: "M. Esquirol possesses, in his anatomical collection, the skeleton of a rachitic female, in whom nearly all the bones of the limbs and trunk are covered with the traces of fractures more or less well united; several of them are broken in two, three, or four points of their length. These fractures, more than two hundred in number, appear to have occurred at different times, judging from the varying states of the callus." It is not easy to say what was the real nature of this remarkable case, but it is scarcely likely that it was one of ordinary rachitis; more probably it belonged among the now recognized tropho-neuroses.

As a general rule, when rachitic children survive the period of the second dentition, the skeleton acquires firmness, and even becomes remarkably dense and strong. Hence it might be questioned whether the adult cases just quoted should fairly be regarded as belonging under this head. But the condition known as *mollities ossium*, *malacosteon*, or *osteo-malacia*—"softening of the bones," in plain English—would seem really to differ very little from that which in children goes by the name of rickets; and Jacquemille's patient may have simply passed from one into the other. Rickets, then, would be the mollities ossium of children, mollities ossium the rickets of adults; an idea long ago suggested. But this view must not be too implicitly accepted, since in rickets, although the pathological changes noted in the bones are more those of subacute inflammation, there is little or no pain; while in the mollities ossium of adults, a disorder in which fatty degeneration seems to be a very important element, the pains are excessive. The tendency of the former, under anything like favorable circumstances, is toward spontaneous cure; recovery from the latter has never yet been recorded. Of the published cases of mollities, the subjects have been for the most part females. In some, large amounts of phosphates and of "animal matters" are said to have been excreted with the urine.[2]

Further reference need hardly be made to mollities ossium, especially as it is highly probable that the cases hitherto ranged under this head may be found to belong properly among the tropho-neuroses before spoken of, the changes connected with the bony skeleton being altogether subordinate to those affecting the central nervous system. Such would seem to be the explanation, in the light of the science of our day, of the classical cases recorded by Curling, Solly,[3] Saviard,[4] and others.

I ought, however, to remark that in some instances the softening is limited in extent; thus in a case reported by the late Dr. Neill,[5] one femur only seemed to be affected. The theory of the neurotic origin of the disease is not here set aside, but we have simply to suppose that a portion only of the central nervous system has undergone pathological change, and that as a result there is degeneration of that part of the skeleton which is dependent upon the tract so involved.

Fragilitas ossium, or brittleness of the bones, differs from the already mentioned predisposing causes of fracture in being not as much a disease as a peculiarity. Sometimes it is seen in old people, as one of the changes incident to their time of life; but it has also been observed as a congenital condition, and in rare instances as a matter of heredity, so that many members of a family, and even several generations, may manifest it. From the published accounts, it does not appear that the bones of persons affected with fragility are always, or even generally, small or slight, and their muscular development would seem to be quite equal to the average standard. A few instances only need be here quoted at length.

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[1] Article "Fractures," Dict. de Médecine. Paris, 1824.

[2] Solly, Med.-Chir. Trans., vol. xxvii. p. 443; MacIntyre, ibid., vol. xxxiii.; Chambers, ibid., vol. xxxvii.

[3] Curling, Med.-Chir. Transactions, vol. xx.; Solly, ibid., vol. xxvii.

[4] Malgaigne, op. cit., tome i. p. 21; Translation, p. 33.

[5] Am. Journal of the Med. Sciences, July, 1874.

Dr. F. J. Shepherd reported to the Medico-Chirurgical Society of Montreal[1] a case of senile atrophy of the bones, with very remarkable fragility, in a woman aged between 80 and 90.

Tyrrell[2] thus reports a remarkable case of brittleness of bone in a man whose age is not given:—

> He had been the subject, at the time he was last under my hands, of seventeen fractures; and when I last saw him, three or four years ago, he had had five more fractures, making in all twenty-two. These fractures affected the femur, the tibia and fibula, the upper arm, and the forearm—scarcely a cylindrical bone of any size had escaped. In consequence of these fractures he had lost in height from seven to eight inches. The first time I had him under my care was in consequence of fracture of the thigh-bone, and the other had been fractured once or twice previously. In consequence of indifferent surgery, that limb was shorter by three inches than that for which he came under my care. He had worn an iron to make up for the difference in the length of the two limbs, and it enabled him to make progression with some inconvenience. Finding this, I stated that it was possible to set the recently broken limb to the same length as the one formerly broken, and at his wish I did so. I made an angular union of the second limb, reduced it to the same length as the other, and he was enabled afterwards to make progression more easily and rapidly. Hence I was the instrument of taking off three or four inches from his height, by shortening the limb to that extent.

It may not be anticipating too much to say here that it is difficult to see how walking could have been facilitated by making the leg crooked; and the experiment is certainly one which surgeons of the present day would hesitate to try.

Gibson[3] gives the following case of his own:—

> A patient of mine, a Mr. Green, residing near Trenton, N. J., has a son now nineteen years of age, who, from infancy up to the present period, has been subject to fractures from the slightest causes, owing to an extraordinary brittleness of the bones. The bones of the arm, forearm, thigh, and leg, have all been broken repeatedly, even from so trivial an accident as catching the foot in a fold of carpet whilst walking across the room. The clavicles have suffered more than any other bone, having been fractured eight times. What is remarkable, the boy has always enjoyed excellent health, and the bones have united without much difficulty or much deformity. The above was published in 1824; since then this patient died, in the twenty-third year of his age. . . . Altogether he had experienced twenty-four fractures.

Stanley[4] speaks of a boy aged ten, under the care of Mr. Earle, in St. Bartholomew's Hospital, "who had suffered eight fractures, six in one tibia, and two in the femur. Each fracture of the tibia occurred in a different part of the bone, and had united within the usual period."

In a case reported by Arnott,[5] a girl aged fourteen years was under treatment for her thirty-first fracture; the right thigh having been broken seven times, the left six; the right leg nine times, the left once; the right arm four times, the left three; and the left forearm once. Her sister, six years old, had had nine fractures since the age of eight months. Neither of her parents nor their families had shown any such susceptibility, nor had it appeared in another sister, or in two brothers.

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[1] Medical News, Nov. 18, 1882.

[2] St. Thomas's Hosp. Reports, vol. i. 1836.

[3] Institutes and Practice of Surgery, 8th ed. (1850), vol. i. p. 234.

[4] A Treatise on Diseases of the Bones. London, 1849.

[5] London Med. Gazette, June 15, 1833.

Agnew[1] mentions a child seen by him who had twice broken the same thigh; he was one of a family of six children, every one of whom had suffered from fracture, two of these three times each. The father had had syphilis, a fact which was supposed to account for the fragility of the bones of his offspring.

Gurlt quotes from Axmann another case, in which three brothers showed this tendency to the occurrence of fracture.

Of fragility affecting the bones in several generations, a very few instances have been given, but they are beyond doubt.[2] Goddard[3] saw a boy aged twelve, who had had fourteen fractures, all from slight violence; his mother had broken her right thigh once, and her left five times; and her brother, at thirteen years, had suffered two fractures of one thigh, and nine of the other, as well as two of the arm. "These people," says the record, "are of very short stature, and have small bones."

Pauli[4] gives the history of a family in the parish of Offenbach, "three of whom had twice, and one thrice, broken an arm and a leg, while one had five times suffered fractures of one or another limb, slight force only having been as a rule sufficient to produce the lesions. Both the father and grandfather had had bones broken. The family were otherwise healthy, and presented no discoverable dyscrasia. It is remarkable that none of them sustained fractures before they were eight years of age. The fractures united very quickly, so that the callus was generally perfectly firm by the end of three weeks. But if the same bone was broken a second time, union did not take place."

In a case reported by Greenish,[5] a boy aged 18 had himself had thirteen fractures; his grandfather had had "numerous" fractures; his father one; his uncle two; his five cousins (children of his uncle), eight, four, four, four, and three respectively; his own brother, two. One uncle and his two daughters had escaped.

[The editor has recorded a case in which, without apparent reason, seventeen fractures had been sustained by the bones of the right lower extremity; when this patient came under observation, multiple enchondromata had been developed in the foot and ankle.]

A few words may be said on the influence of *age*, *sex*, and *occupation* upon the liability of individuals to fracture; they are so closely connected in this respect that they may be considered together.

Until about the age of puberty, the habits, plays, and occupations of boys and girls are very much alike, and one might naturally suppose that their bones would be broken with about equal frequency. Yet according to Malgaigne, from two to five years of age, "the number of girls affected with fracture was nearly double that of the boys;" while Gurlt[6] gives the proportion: from one to four years $1\frac{1}{2}$ times as many, and from five to eight years $2\frac{1}{3}$ times as many boys as girls. The two authors just quoted agree in saying that between the fifteenth and twentieth years of life about eight times as many fractures occur in males as in females. Malgaigne thinks that the disproportion then steadily diminishes, until "beyond seventy-five years there are nearly twice as many fractures in women as in men;" but Gurlt makes the proportion between twenty-one and thirty 10 times, and between thirty-one and forty 11½ times as many male as female cases. Then, according to the latter author, a decrease does occur, and from seventy-one to eighty the women are 2½ times, and from eighty-one to ninety 7 times, as often affected with fractures as men. I shall make no attempt to reconcile or explain the differences between these estimates, coming from such distinguished sources.

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[1] Principles and Practice of Surgery, vol. i. p. 718.

[2] Ekmann's case, quoted by Gurlt from Acrelius (A. D. 1788), seems to me not to belong in the present category, but to have been simply an instance of hereditary rachitis, as far as the vagueness of the account enables one to judge.

[3] Gibson, op. cit., vol. i. p. 236.

[4] Untersuchungen und Erfahrungen im Gebiete der Chirurgie, 1844; quoted by Gurlt, Handbuch der Lehre von den Knochenbruchen, Bd. i. S. 149.

[5] Brit. Med. Journ., June 26, 1880.

[6] Op. cit., table on p. 9.

Children sustain fractures mainly as the result of falls; but they are very liable to be hurt in this way, partly from their lack of muscular strength, partly from their heedlessness and love of adventure. Occasionally they put themselves in danger from the kicks of horses, or from being run over; I once had to amputate the arm of a little fellow, only seventeen months old, for compound fracture caused by the wheel of a passenger railway car.

After puberty, the rougher sports of boys render them much more liable than girls, not only to falls, but to other forms of violence; and during adult life, many of the occupations followed by men are attended with numerous exposures from which women are almost wholly exempt. Our hospital wards afford daily evidence of the liability to fracture among painters, carpenters, masons, drivers, and laborers of all kinds.

With the advent of old age, the habits of the two sexes become again much more nearly alike, and the accidents to which both are exposed resemble those which are apt to happen to children. Senile feebleness, and the timidity which comes with it, is curiously similar in its effect, in this way, to the ignorant and heedless weakness of childhood. And the slighter frames of women yield more readily to sudden strains, so that the excess in the number of their fractures is not a matter of wonder.

Not only is the frequency of fractures influenced by the causes just discussed, but their character also. In children and in the youth of both sexes, we have to deal mainly with fractures (sometimes incomplete) of the shafts of the long bones, and with epiphyseal disjunctions. In adults we meet with injuries of the former class, and (chiefly in the male sex) with fractures by crushing, as in mining, railroad, and machinery accidents, and falls from heights. Among old people, the bones are more apt to give way, from slight force, at weak points; thus in them fractures of the neck of the femur are very common. But these points will be again referred to more particularly.

Drunkenness has been spoken of by some authors as a source of immunity from fracture; and in proof of this idea cases are adduced in which persons have fallen from considerable heights, while under the influence of liquor, without sustaining any injuries beyond contusions. But there are very many instances known in which sober people have likewise escaped fractures; and on the other hand, a large proportion of the patients admitted into hospitals, or treated in private, for this class of hurts, have received them while drunk. The only way in which intoxication can prevent fracture is by relaxing the muscles, and thus rendering the limbs flaccid. Under such circumstances one of the conditions of indirect force as a cause of fracture is set aside, and the bones, if broken, yield to direct violence or crushing.

The influence of *season*, and especially of cold weather, as a predisposing cause of fracture, was insisted on by some of the older writers, who maintained that the bones were more brittle in winter. This idea need hardly be gravely refuted. When the ground is frozen hard, and rendered slippery by ice and snow, falls upon it are perhaps more apt to result in fracture of bones; but on the other hand, in milder weather, out-door occupations are more extensively carried on, whether in the way of work or of sport, and a great many accidents occur to those engaged in them.

Something may now be said of the *local* predisposing causes of fracture.

The *exposed situations* of certain bones, and of certain portions of those bones, render them especially liable to breakage. Tables are given by systematic authors, derived mainly from hospital records, showing with more or less accuracy the relative distribution of fractures over the skeleton, from a comparison of large numbers of cases. Such tables, as far as I have been able to find and compare them, agree in sustaining the following general statement of the comparative liability to fracture of the different portions of the skeleton: The greatest number of fractures occur in the bones of the leg; then follow the thigh, the arm, the forearm, the clavicle, the ribs, the facial bones (including of course the lower jaw), and the patella. A more detailed exhibit would scarcely be of practical value here, but can be found in the writings of Malgaigne, Gurlt, Norris, and others, by those who may be interested in the matter.

Inflammation of a bone has been assigned as a cause of such weakening of its texture as to render it apt to give way. Nicod's two cases, quoted by Malgaigne,[1] seem to bear this explanation; in each the patient had had pains for about a month in the humerus, which broke under very slight stress.

Caries and *necrosis*, by depriving a bone of a portion of its thickness, may lead to the snapping of the remainder.

Tubercle of bone may so alter it as to make it unequal to the resisting of fracturing forces; and in a very few instances the same result has been recorded of *cystic or hydatid tumors.* For details of five such cases, the reader is referred to Gurlt.[2] With regard to the development and natural history of *sarcomata* of the long bones, by which they have sometimes been similarly affected, much information may be found in a paper by Dr. S. W. Gross.[3] The central sarcomata would seem to be those most apt to weaken the bony structures so as to predispose them to fracture.

SPONTANEOUS FRACTURES.—*Spontaneous* fractures, so called, are such as occur without any apparently adequate cause. Thus Erichsen[4] says that he knew a gentleman a little over fifty years of age, seemingly in perfect health, whose thigh gave way with a loud snap as he turned in bed. Gross[5] mentions the case of a gentleman aged 54, who broke his femur in pulling off a boot. Other like instances are on record.

In a larger class of cases, there is evidence more or less clear of a precedent diseased condition of the bones; and to designate these, Prof. Broca[6] suggested "pathological" as a more accurate term. Thus there may have been previous complaint of pain at or near the seat of fracture; and in some cases malignant disease has been present at the time, as in those recorded by Salter and S. Cooper.[7] Sometimes there is a local development of the disease in the bone, previous to its giving way, as in the case quoted from Petit by Malgaigne;[8] or again, the fracture is the first sign of the bone becoming affected, as in an instance recorded by myself.[1] Hydatids (cysticercus cellulosæ) are sometimes found in bone, and the first indication of the disease has sometimes been the occurrence of fracture without apparent cause.[2]

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[1] Op. cit., tome i. p. 23; Translation, p. 34.

[2] Op. cit., S. 193.

[3] American Journal of the Medical Sciences, July and October, 1879.

[4] Science and Art of Surgery, 1873 (Am. ed.), vol. i. p. 303.

[5] Op. cit., vol. i. p. 899.

[6] Gaz. des Hôpitaux, 15 Avril, 1876; Med. Times and Gazette, May 13, 1876.

[7] Salter, Med.-Chir. Transactions, vol. xv.; Cooper, ibid. vol. xvii.

[8] Op. cit., tome i. p. 13; Translation, p. 26.

Still another set of cases are thus known, in which the bones give way under abnormal muscular action, as in epileptic or other convulsions. Lente[3] has recorded an instance in which both femora were so fractured. Van Oven[4] reported a fracture of the femur, by cramp coming on during sleep, in his own person. Many other cases have been published, some of which will be hereafter referred to in connection with the special bones involved. As a general rule, if the muscular action be not clearly pathological, such as that exerted in epileptic states, it is sudden and forcible; and the fact can often be demonstrated that the bones thus broken are taken at a mechanical disadvantage. Sometimes, as I shall point out in regard to certain parts of the skeleton, there is a probability of leverage being the true explanation of these apparently causeless yieldings.

It will therefore be seen that the term "spontaneous," if used at all, should be clearly understood either to refer only to the first of the classes of cases just enumerated, or to have a simply conventional meaning, namely, that the force producing the fracture is not obviously adequate to the breaking of a sound bone. For it cannot be imagined that turning in bed, for instance, or throwing a chip, should involve sufficient strain upon the structure of a normal femur or humerus to cause the fibres to give way. Indeed, in the first class of cases, it may be regarded as almost certain that some pathological change had taken place in the bones, although undetected; the accounts do not state whether or not there was any further evidence of disease, but such a thing is quite possible.

As to the third class, any one familiar with the fearful force of muscular action often manifested by patients affected with epilepsy or tetanus, will see the absurdity of applying the word "spontaneous" to fractures occurring under such circumstances.

Nothing ever occurs spontaneously, either in normal or in pathological phenomena; although it may be that the chain is not traceable without closer observation or clearer insight than is brought to bear upon it.

Mechanism of the Production of Fractures.

It has already been remarked that the main function of the bony skeleton, and of each of its component parts, is mechanical, and is carried on in accordance with the known laws of mechanics. Further than this, each bone is a member of a system, made up of two or more bones, united together by ligaments, and moved upon one another more or less freely by the action of muscles, so that the mechanical conditions involved are somewhat complex, and can only be arrived at by the study of the structure, form, and connections of the members of each system. When the strain put upon a bone is beyond its power of resistance, its fracture takes place in obedience to the same laws, and under the influence of the same conditions. Hence, if any one studies a large number of fractures, placing them in series according to the portion of the skeleton involved, he may readily note a certain uniformity which prevails among the different members of each series. Variations do indeed exist, but they are traceable to differences, perhaps slight, in the character, direction, or exact mode of application of the fracturing force, or in the conditions of resistance, or perhaps in the shape of the bones themselves. The dominant lines of breakage are singularly constant; and although they have been pointed out in regard to certain special fractures, they have been overlooked in the general study of these injuries.

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[1] Malgaigne, Translation, p. 26.

[2] Stanley, op. cit., pp. 190, 194; Wickham's case, from London Medical and Physical Journal, vol. lvii.

[3] Amer. Med. Times, July 21, 1860.

[4] Med. Times and Gazette, Dec. 25, 1852.

No such uniformity exists in the case of china, marble, or plaster. A bowl or statue, struck or thrown down, may be shattered into fragments of the most fantastic and apparently capricious shapes. Or if several exact models of a femur were made in plaster, and force applied to them, they would be cracked, shivered, or broken off short, in the most irregular way. The annexed outline (Fig. 581) is taken from a cut which has been used by eminent authors as a representation of extracapsular fracture of the cervix femoris; but I will venture to say that no one ever saw such a fracture, and that any one will be convinced of its impossibility who will look at a vertical section of the head and neck of the femur. What the dominant lines really are, will be shown when the discussion of fractures of this part comes in order.

Fig. 581.

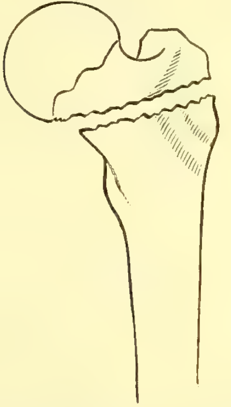

Diagram supposed to represent extra-capsular fracture of the cervix femoris. An impossible line of fracture.

Only a brief review can be given here of the mechanical conditions of the skeleton; but the general principles laid down will be found to be verified in the case of special bones and their fractures.

Upon an exterior survey, it is at once seen that the long bones are narrow in their shafts, and expanded at either end for the purpose of strengthening the articulations. It will be also noted that they are almost without exception curved, and that many of them are twisted in a marked degree. These irregularities of form are more pronounced in some skeletons than in others. Some of the bones, notably the lower jaw and the femur, are strongly bent.

Upon making sections—of the femur for instance, this bone affording the most striking example—it will be seen that the shaft consists of a tube, with thick and strong walls, which gradually pass toward either end into a thin shell, filled with a network of cancellous bony tissue, of which more will be said presently. The aggregate of osseous substance is the same throughout; so that an inch of the length, taken from the middle of the shaft of the femur, will weigh about the same as an inch of the length cut near either end. Sections of the pelvis and scapula will show a very analogous arrangement between their flat and their spongy portions; and the same may be said of the vertebræ. In other words, the structure of all bones is adapted to the bearing of either strain or pressure, or both. Where, as in the shafts of the long bones, strain is to be provided for, the material is massed in tubes of adequate thickness of wall; and it will always be found that this thickness is greatest on the concavity of curves. On the other hand, where, as at the articulating ends, pressure is to be sustained, the bony substance is spread out so as to give surface. Allusion was just made to the backing up of the thin shell, thus formed, by reticular tissue; and this deserves special notice.

Everywhere in the spongy bones, as well as in the articular ends of the long bones, the lamellæ forming this network run at right angles to the surface, so as to receive the pressure directly upon their extremities, and thus to afford the greatest possible strength. Sections, vertical or transverse, of the bodies of the vertebræ, of the astragalus, of the carpal or tarsal bones, or even of the articular ends of the phalanges, will show this law; and it will be further noticed that, in any of these cases, if the surface to receive pressure is concave, the shell of bone is thickened accordingly.[1]

If now the lines of muscular traction be considered, the further fact will appear that it is invariably exerted so as to bear in the *length* of these columns of bony tissue, whether of the shafts or of the extremities of the long bones, or of the mass of those more or less cubical in shape. The ribs, pulled upon by the intercostal muscles at their upper and lower margins, are filled from end to end with cancellous tissue, so arranged as to take the strain thus imposed, while other lamellæ, placed transversely, meet the effect of pressure; hence these bones, although long in shape, are analogous to the so-called thick or round bones in structure. In looking at the relations of the ribs to muscles, it must not be forgotten that very powerful strain is brought upon these bones by some of the muscles acting on the upper extremity; but it will be found that in this respect also the same law as to the distribution of stress is carried out, so as to reduce it to a minimum for each portion of each bone.

The lines of tension of the muscles always form more or less acute angles with the axes of strength of the bones acted upon by them; and this rule is more close and definite in proportion to the length and power of the muscular masses concerned.

From what has now been said, it will probably be apparent that the arrangement of the bony material is such as to adequately provide for meeting all the stress to which it is normally exposed. Let it be recalled, however, that each bone is but a member of a mechanical system of levers, and hence that the force brought to bear upon it may be vastly increased, as well as changed in direction, so as to take it at a disadvantage. Under these circumstances, its texture gives way to what is called in mechanics a "cross-breaking strain." The obliquity of most fractures with regard to the long axis of the portion of bone involved, to be presently noticed as almost if not altogether universal, is an additional proof of the correctness of this view.

Now the prevalence of this mechanism, together with the systemic relation of each bone, above recalled, may serve to explain in great degree the existence of the dominant lines of breakage to which reference has been made, and which will be further spoken of in connection with special fractures.

A bone being broken across, it will easily be seen how in very many instances one of its fragments may engage in the other, and act as a wedge to split it into two or more smaller fragments.

The natural curves of the long bones, and the slight twist which is presented by the longitudinal axes of many of them, although of advantage in their normal function, may render their fracture easier under certain circumstances.

Of all these mechanical conditions, instances will present themselves in connection with special fractures; and the general statements now made may suffice for the present.

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[1] The reader will find this subject well set forth and illustrated in Wagstaffe's Student's Guide to Human Osteology, London, 1875; and by Wyman, Trans. Am. Med. Assoc. for 1850. It has been almost wholly overlooked by systematic writers on anatomy.

VARIETIES OF FRACTURE.

A good many terms have from time to time been suggested with a view to the designation of peculiarities presented by these injuries, but only a few are or need be retained. Confusion has arisen from the employment of some of these terms in different senses by different authors; it is therefore especially necessary to define them as they will be used in the following pages. With regard to some of the varieties, the mere definition will suffice; but of others I shall have to speak more at length, and will do so here for the sake of convenience.

SIMPLE AND COMPOUND FRACTURES.—A *simple* fracture is one to which the atmosphere does not find access, the soft parts remaining so far intact as to exclude it. There may be very extensive injury of all the tissues, and the skin not divided; or there may be a gaping wound of the skin, and the muscles and fasciæ untorn; but in either case, the fracture is still a simple one.

When the external air is admitted to the broken portion of bone, whether by the action of the fracturing force wounding the soft parts from without, or by the thrusting of the fragments through the skin, the injury is called a *compound* fracture.

A fracture, at first simple, may become compound by a process of sloughing or ulceration, or by suppuration; and conversely, a fracture, compound either primarily or secondarily, may become simple by the healing of the external wound and the consequent exclusion of the air.

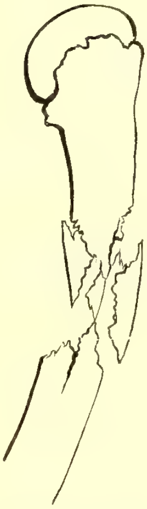
Compound fractures, as would naturally be supposed, vary extremely in severity; but they are always more serious than the same amount of bone-injury would be if not exposed to the air. Sometimes the opening in the skin is but small, yet the bone is very extensively crushed and splintered, and the other soft parts have been torn and bruised beyond repair; sometimes the bone suffers very largely, while the soft parts are very little injured; sometimes the wounding of the tissues about the bone is greatly in excess, the bone itself being merely broken across; and in some cases a formidable laceration of the skin may attend upon comparatively trifling hurts to the deeper soft parts and to the bone itself.

Railroad, machinery, and mining accidents, and falls from heights, are the most frequent causes of compound fractures, which may, however, be produced by much less formidable forces. I have several times seen these injuries, so grave as to require amputation, the result of slight falls. An attempt to rise and walk will sometimes convert a simple fracture of the leg into a compound one, by the ends of the fragments penetrating the skin. Occasionally the seat of fracture is laid bare secondarily by the occurrence of suppuration or by sloughing of the superjacent soft parts; but here the gravity of the condition is not dependent upon the mere exposure of the bone.

Compound fractures are more serious than simple, because they involve as a general thing more severe injury to the bone itself; because in them the tearing of the periosteum, an almost invariable accompaniment of any breaking of the bone, is apt to be greater, whence there is more risk of impairment of nutrition—recovery, as will presently be further shown, being thus hindered, rendered more difficult, or prevented; because the violence done to the surrounding soft parts is greater; and because, independently of any septic influence exerted by the atmosphere, subcutaneous injuries of all kinds are repaired more readily than those which are deprived of the protection of the skin. Suppuration is almost sure to follow upon compound fracture: it is only in very rare instances that the immediate closure of the wound can be effected.

It is in compound fractures, more frequently than in any other class of injuries, that the question of amputation is raised. For the discussion of the conditions requiring it, the reader is referred to the article on Amputation.[1] The treatment of compound fractures not calling for the removal of the limb, will be considered in connection with that of fractures generally.

Fig. 582.



Comminuted fracture.

Multiple, Comminuted, and Impacted Fractures.—When there are two or more distinct breakages, whether of the same bone or of different bones, the case is said to be one of *multiple* fracture.

When there are several fragments, the fracture is said to be *comminuted.* (Fig. 582.) Sometimes there is one main line of breakage, and the end of one or of both fragments is split or shattered into several smaller ones. (See Fig. 583, *d.*)

Impacted fracture is said to exist when one of the fragments penetrates the other, and is so wedged into it as to limit or prevent their mobility upon one another. Usually there is first a partial separation, and then either by external force or by muscular contraction the wall of one fragment is driven into the cancellous structure of the other.

Multiple fractures are generally produced by very great violence, such as railroad or machinery accidents, or falls from heights; forces being exerted either at the same moment, or successively, upon different portions of a limb or of the body. They derive their gravity either from the amount of injury inflicted, and the consequent shock to the system, or from the difficulty involved in the application of proper dressings.

Some years ago a man was brought to the Episcopal Hospital, who, while drunk, had been run over by a "dummy" engine as he was stooping down to hunt for his pipe on the ground. Almost all the bones in his body seemed to be broken, except those of the head; his ribs were smashed; his pelvis ground up so that it felt like a mass of loose stones, and his extremities could be twisted about in any direction. He died about an hour after the alleged time of the accident.

In December, 1881, a colored man, aged 32, was brought to the Episcopal Hospital, having been injured by a derrick falling upon him. He presented but slight symptoms of shock, but died in about two hours. On examination it was found that eight ribs on the left side were broken, and seven on the right; on the left side the pleura was wounded, and the eighth intercostal artery was divided by a spiculum of bone; on the right side four of the ribs had injured the pleura, and two had penetrated the lung also. In each pleural cavity there were a number of spicula of bone. Fractures of the spinous and transverse processes of the second, third, fourth, and fifth lumbar vertebræ, and on the left side division of two lumbar arteries by spicula, causing large hemorrhage into the areolar tissue, were noted. There were also oblique fractures of the right femur in its lower third, and of the left fibula in its upper third, with rupture of the internal lateral ligament of the knee.

Gross[2] speaks of an old woman, who, by a fall from a third story window, sustained no less than eighty-three fractures.

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[1] Vol. I. p. 560.

[2] Op. cit., vol. i. p. 898.

Less interest attaches, however, to cases such as those just given (the list of which might be almost indefinitely extended), which are inevitably fatal, than to those in which only two or three fractures are sustained, and in which the treatment presents points of much difficulty.

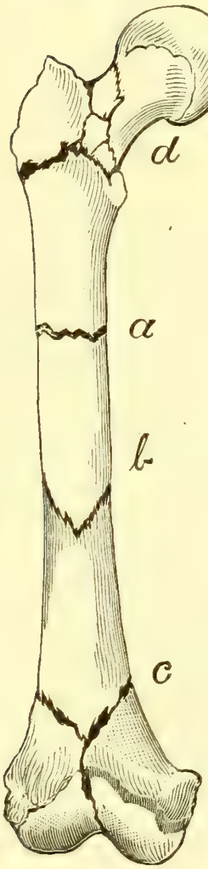
In April, 1882, a boy, aged 14, was brought to St. Joseph's Hospital, having been carried ten times around a revolving shaft. He had fractures of the right humerus, radius and ulna, and femur, and of the left radius and ulna; also dislocation of the hip and elbow on the right side. There was marked shock; but he ultimately made a good recovery.

I was called, in 1881, by Dr. Downs, of Germantown, to a young man, aged 22, who had had his right arm caught around a shaft, and had sustained fractures of the humerus, radius and ulna, and metacarpus. The swelling of the whole limb and shoulder was so great as to mask the injuries somewhat, and to interfere with the management of the case; but, as it subsided, we succeeded in getting the bones into good position, and an almost perfect restoration of all the functions of the part was effected.

When a part contains two bones, and a fracture of both is caused by the same violence, although at such different levels that the two lesions are quite separate, the case is not said to be one of multiple fracture;[1] nor is the term applied to cases where several ribs are broken, unless the injury should affect both sides, or be not only at different points, but due to forces acting distinctly only on those points. Two or more separate fractures, each requiring special attention in the way of treatment, must exist in order to bring the case properly under the present head.

Of course, very various combinations of fractures may present themselves, and must be dealt with according to the best judgment of the surgeon. Some of these combinations will be referred to more in detail in speaking of fractures of special regions.

Fig. 583.



Transverse, oblique, and longitudinal fractures.

Transverse, Oblique, and Longitudinal Fractures.—Fractures are further divided according to their direction, into *transverse*, *oblique*, and *longitudinal;* these terms having reference to the relation of the line of fracture to the longitudinal axis of the portion of bone involved. (Fig. 583; *a*, transverse; *b*, oblique; *c*, mixed oblique and longitudinal.)

Transverse fractures, strictly speaking, are extremely rare. Occasionally they are met with in the succulent bones of the very young, and sometimes as the result of extreme violence. I once saw a thigh-bone broken directly across by the impact of a heavy charge of shot at very close range. But as an almost universal rule, a greater or less amount of obliquity may be looked for in fractures; a fact which has already been alluded to in support of the leverage theory of the mechanism of the production of these injuries.

Longitudinal fractures are also very rare, except as subordinate to other lines of breakage. Fig. 584, copied from Holmes's "System of Surgery," represents a remarkable instance of a tibia split for a considerable portion of its length. Generally, the fractures called longitudinal are merely extremely oblique, so as to be nearly parallel to the axis of the bone. It almost always happens that the fragments are *serrated* along their margins, by the irregularity with which the fibres give way. Sometimes the serrations are fine and close, but oftener the line of fracture is extremely jagged, and presents several strongly marked, tooth-like processes. The proper coaptation of these edges may be very difficult, by reason of their interlocking; but if it be once effected, they serve to prevent the reproduction of the displacement. It will readily be perceived that projecting portions of the fragments are apt to be broken off, and that they may occasionally give rise to much trouble by acting as foreign bodies.

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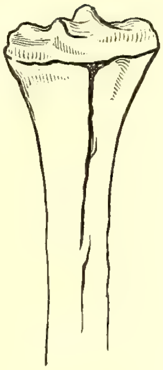
[1] Non-professional people often say that a man had his leg "broken in two places," when they merely mean that both bones were broken.

Fig. 584.



Longitudinal fracture of tibia.

VARIETIES OF INCOMPLETE FRACTURE.—So far, reference has been made only to *complete* fractures, in which the whole thickness of the bone is broken through. It remains to say something of *incomplete* fractures—a term which embraces a variety of forms of injury.

Fissures or cracks need hardly be formally defined here. They occur mostly as accessory to complete fractures, from which they branch off, frequently in a spiral course. In the flat bones, and especially in those of the cranium, they are often met with, and may be stellate, radiating, or camerated. Very rarely, they exist alone in the long bones, as the result of violence not quite sufficient to break the whole thickness of the shaft; in such cases they may be unsuspected until much and long-continued mischief has been caused. Some of the recorded instances will be referred to in connection with the special bones concerned.

Splintered fractures are such as consist in the detachment of a small portion, generally an edge, of a bone, the main body of which is left intact. They are seen occasionally at the brim of the pelvis, or at the spine of the tibia; but for obvious reasons they may readily pass unrecognized unless attended with a wound making them compound.

Perforations of bone are always compound fractures, and almost invariably the result of gunshot injury; the reader is therefore referred, for information concerning them, to the article on Gunshot Wounds.[1]

Sprain fractures have been already briefly mentioned under the head of "fractures by avulsion," as those in which small fragments of bone are pulled away by excessive stress put upon the ligamentous fibres attached to them. Thus Bruce[2] has published a case in which, by a fall from a second story window, a boy aged 12, had a piece torn out of the right tibia, and one out of the left femur, in each instance by the anterior crucial ligament. And Dittel[3] is reported to have met with an instance in which the spine of the tibia was thus wrenched away in a man who was violently kicked in the ham. Cases are referred to as observed by Poncet, and one at the University College Hospital, in London, in a boy aged 11, who had been run over by a cart. Dittel failed to produce this lesion experimentally on the dead subject.

Shepherd[4] has described a fracture of the portion of the astragalus into which the posterior fasciculus of the external lateral ligament of the ankle joint is inserted, which probably belongs in this class. He exhibited four specimens, all however taken from bodies in the dissecting-room, and without history.

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[1] Vol. II. pp. 119 *et seq.*

[2] Trans. of the Pathological Society of London, vol. xviii. 1867.

[3] Med. Times and Gazette, Sept. 30, 1876 (from Centralblatt für Chirurgie).

[4] Med. News, June 10, 1882.

Callender, who I believe first gave the name of "sprain-fractures" to these injuries,[1] suggests that the bit of detached bone may remain held by its ligamentous connection, but, failing to unite, may act as a foreign body, occasionally getting caught in the joint. Of this, however, there is no known instance.

I have recently seen a case in which the tip of the inner malleolus was torn off in a fall on the ice; whether it united or not I cannot say, but the injury was followed by very intractable lameness. Very little is as yet known in regard to this form of fracture, to which special attention has only recently been attracted; but the injury to the bone adds to the gravity of the case, renders recovery much slower, and may even cause permanent impairment of the functions of the limb. Such cases, there can be no doubt, have often been unrecognized. Crepitus may sometimes be detected, but may be wanting by reason of effusion into the joint or into the tissues, or because the small fragment is separated from the main portion of the bone.

Any case of sprain or other injury about a joint should be carefully examined with reference to the existence or non-existence of this form of fracture, and its possibility, or proof of its presence, should influence the surgeon in making and expressing a prognosis.

Partial fractures are those in which a bone is so acted upon, either by direct or by indirect violence, that some of its fibres are broken, while the rest are only bent. Sticks are often broken in this way, especially when they are green and tough; hence the name "green-stick"[2] or "willow" fracture has been given to this form of injury. And fractures of this kind are especially apt to be met with in the tough and resilient bones of the young, in whom, moreover, the periosteum is proportionately thicker and less apt to be torn through than in later life. Otto[3] says that he has seen incomplete fracture in the radius of a lion, as also in the bones of animals of the deer kind.

Reference may be best made here to the subject of *bending of bones*, about which there has been much discussion, some surgeons maintaining that it is common, and others that it is impossible. Without going into the history of the question, I may say that cases were long since observed, in which, generally in the forearm, distortion, or rather angular deformity, was noticed, but without any of the other signs of fracture to be presently described. Sometimes, indeed, there was pain, and always more or less loss of power; but not the helpless dangling of the limb usual in fracture. Hence it was claimed that the affected bones were not broken, but only bent. Experience, however, showed that whenever dissections were made in such cases, the lesion was found to be incomplete or partial fracture, as above described. It must be admitted that Hamilton[4] succeeded in bending experimentally the bones of young animals; but this does not prove the possibility of such a thing in the human subject; and for practical purposes it is better to regard and treat cases of apparent bending as partial fractures. I believe, indeed, that this would be the true view of bending, if that were shown to exist; that is, that the crumpling up of the bony tissue of the wall on the concavity, would amount to a solution of continuity equivalent to the rupture of the bony fibres of the wall on the convexity in the usual form of partial fracture, and that the difference would be simply that in the former case the convex wall, and in the latter the concave, remained unsevered. Such a result is often produced in the attempt to bend metallic tubes, and may have existed in the really tubular bones which were experimented upon by Hamilton, as above mentioned.

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[1] St. Bartholomew's Hospital Reports, vol. vi. 1870.

[2] "There is also a curvedness which may be reduced to a fracture. I have seen it in children often. . . . . It is as it were when you break a green stick; it breaks, but separates not."—Wiseman, "Chirurgical Treatises," vol. ii. book vii. p. 239, 6th ed. 1734.

[3] Compendium of Human and Comparative Pathological Anatomy, translated by South. London, 1831.

[4] Op. cit., p. 85.

Partial or "willow" fractures are generally produced by moderate force, or by great force acting slowly. Thus in many of the recorded cases they have been the result of slight falls; and Hodge[1] and Parkman[2] have seen them in young men carried around revolving shafts. Farquharson[3] published one in a young man of 18, sustained in a foot-ball match. Two very remarkable cases, due to gunshot, were observed during our late war.[4] They affected the right ninth rib and the left fourth rib, and the patients were aged respectively 21 and 28 years.

The restoration of the shape of the limb is apt to be very difficult, and in its accomplishment the fracture is often rendered complete. Sometimes, however, it has been gradually brought about by nature, apparently as the result of the continuous action of the surrounding muscles.

Epiphyseal separations or disjunctions, met with only in the young, before consolidation by bone has taken place between the diaphyses and the epiphyses, do not differ materially from fractures, although the tissue which gives way is not true bone, but the cartilage-like, osteogenetic matrix. Sometimes in these cases the line of separation seems to be very nearly if not quite transverse. Union generally takes place readily, but the subsequent growth and development of the whole bone has seemed in some instances to have been interfered with.

Hutchinson[5] gives instances of deficient growth in bones which have been the seat of such injuries, and Holmes[6] says that he has several times noted this after fractures in the neighborhood of the wrist. In all cases the child's friends should be informed of the probability of impaired development as a result. Holmes, from a study of the specimens contained in the Museum of St. George's Hospital, is inclined to agree with some of the French surgeons[7] in the opinion that "the line of fracture seldom runs accurately through the epiphyseal cartilage in its whole course."

I shall have occasion to refer to these injuries again in speaking of ordinary fractures affecting special bones in the neighborhood of their articular extremities.

Complicated Fractures.—This term has a special significance in surgery. According to ordinary speech, any coincident condition, such as delirium tremens, tetanus, or disease of the liver or kidney—rendering the treatment more difficult and the prognosis more grave—might be said to complicate a fracture; and so also would the existence of other fractures or injuries, even in distant regions of the body. But, in surgical language, a *complicated* fracture is one along with which there is some serious surgical lesion of neighboring structures.

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[1] Proceedings of the Pathological Society of Philadelphia, vol. i. p. 232.

[2] Am. Journal of Med. Sciences, Oct. 1853.

[3] British Med. Journal, Dec. 4, 1869.

[4] Med. and Surg. History of the War of the Rebellion. First Surgical Volume, pp. 567 and 568.

[5] Transactions of the Pathological Society of London, vols. xiii. and xvii.

[6] Surgical Treatment of the Diseases of Infancy and Childhood, 1868, p. 240.

[7] Gazette des Hôpitaux, 1865.

Thus there may be extensive wounding of the soft parts, but not admitting the air to the broken ends. (Such admission of air would, as before said, make the fracture *compound ;* and while the fact of its being compound really constitutes a complication, there is a propriety, as well as convenience, in limiting the use of these terms.)

Again, the original violence may have not only broken the bone, but also ruptured the adjacent artery or a vein of considerable size, or lacerated a large nerve-trunk. Such rupture or laceration may also be caused by contact with the sharp or jagged edge of one of the fragments.

Or, besides the fracture, there may be luxation of the neighboring joint; or, without dislocation, the joint may have been seriously damaged.

Or, in certain positions, important viscera may have been lacerated or penetrated by the fragments; thus the bladder is apt to be ruptured in fractures of the pelvis, and the lungs, or even the heart, may be wounded in fractures of the ribs.

The amount and character of the influence exerted by these other lesions upon the course of a case of fracture, vary, as might be supposed, very greatly. Some, as wounds of the soft parts, merely embarrass the surgeon in his treatment; others, like luxations, require special measures for their relief; or, if uncorrected, will, in a marked degree, vitiate the ultimate usefulness of the limb. Injuries of vessels or nerves, superadded to fracture, may necessitate amputation.

But there is a large class of complicated fractures—those in which the viscera are wounded—in which the gravity of the complication is apt to be such as to altogether overshadow that of the fracture. These cases may be amenable to surgical treatment, as, for example, when the bladder is ruptured in fracture of the pelvis, and success depends upon preventing the escape of urine, either into the surrounding areolar tissue or into the peritoneal cavity; or they may come within the province of the physician, as when a pleurisy is set up by a broken rib. Sometimes the lesion complicating the fracture is necessarily fatal, as in the case of a wound of the heart.

Further reference to these various complications will be made in connection with fractures affecting special bones.

There is still another class of complications of fracture—those, namely, which arise secondarily, from the occurrence of inflammation in neighboring parts. Thus it occasionally, though rarely, happens that an abscess is formed either about the fragments, in the soft parts close by, or in a joint. Under such circumstances, the treatment of the fracture itself may be seriously interfered with, and the prospect of restoration of usefulness to the limb much impaired.

INTRA-UTERINE FRACTURES.—Notwithstanding the mobility of the fœtus, and its protection by the amniotic liquid and by the maternal body, its bones are occasionally broken. These injuries are generally due either to blows or to other violence inflicted from without through the belly of the mother, or to abnormal contraction of the muscles of the child itself. In one or two instances, one of twins has sustained fracture apparently from entanglement of its limbs with those of its fellow.

When external violence is the cause of these fractures, the effect is, of course, limited to those bones on which it falls. Of this many instances have been published, and are quoted by Malgaigne and other systematic writers. Only a few points need be noted here.

Sometimes union has already taken place at the time of birth; as in the case reported by De Luna.[1] A woman aged 32, at the middle of the ninth month of pregnancy, fell down stairs, striking her belly against a wooden tub. Pain, not very severe, and faintness followed. The child, when seen by the reporter, was four weeks old, and had "fracture of the clavicle near the acromial extremity, united by bony callus, with considerable overlapping."

In one case recorded by Rodrigue,[2] the humerus was dislocated, and both bones of the forearm of the same side were broken and firmly united at an angle of about 45°.

Sometimes the fragments have projected, and have been felt by the mother irritating the walls of the womb.

Although the bones in many instances have become solidly united before birth, it occasionally happens that no union takes place. Thus, a case is recorded by Mr. H. Smith[3] in which the tibia and fibula, broken within the womb, were still ununited when the child was seven years old. One curious instance is quoted by Gurlt,[4] from Maeder, in which a woman seven months pregnant fell from the top of a ladder, and subsequently lost, at first blood, afterward blood and water, from the vagina; she had also persistent pains in the belly, but no loss of general health, and her confinement was normal. Her child, a strong boy, was born wanting the left upper extremity from the middle of the arm, where the white bone protruded through a reddish-brown, moist, but not bleeding or suppurating wound, which soon healed up. The separated limb came away with the after-birth; it seemed to have undergone maceration. This case, which stands alone, as far as I can ascertain, admits of only one explanation, which suggests itself.

It is scarcely worth while to dwell here upon the cases in which very numerous fractures have been seen in the fœtus, as in most of them there is no question that they were the result of diseased conditions of the skeleton, and it is probable that this was the true explanation in all. Sometimes it is clearly from deficient ossification between the diaphyses and epiphyses.

Thus, Barker[5] reported a case in which all the long bones of the extremities were broken, and the frontal, parietal, upper part of the occipital, and squamous portion of the temporal were absent. On examination, the skeleton was found deficient in inorganic matter, except in certain enlarged portions which contained an excess.

Brodhurst,[6] in a paper read before the Royal Medico-Chirurgical Society, suggested the connection between these lesions and other congenital defects, such as distortions of the feet and hands. In the discussion which followed, Messrs. Little and Pollock spoke of cases which they had seen with deficiencies of fingers and toes; and Mr. Adams said that the limbs in such cases did not grow normally.

Davies[7] has reported a case in which a man, grown up when seen by him, had had an intra-uterine fracture of the leg, in which this defect of growth was very marked.

Of *fractures sustained during birth*, very little need be said. They are sometimes caused by the powerful expulsive contractions of the uterus; as in a case reported by Vanderveer.[8] But they are for the most part due to the operations of the accoucheur. Gibson[1] says that he has seen the clavicle give way from an ignorant midwife pulling at the arm. Malgaigne mentions a number of cases of epiphyseal disjunctions thus produced; in one, the lower epiphysis of the femur and the upper epiphysis of the tibia were separated at the same time by traction on the foot. In the use of the blunt hook such accidents sometimes occur, and cannot always be avoided even by the most dexterous and careful operators.[2]

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[1] Am. Journal of the Med. Sciences, July, 1873.
[2] Am. Journal of the Med. Sciences, January, 1854.
[3] Trans. of the Pathological Society of London, vol. xviii. 1867.
[4] Op. cit., Bd. i. S. 222.
[5] British Medical Journal, Sept. 26, 1857.
[6] Med. Times and Gazette, April 7, 1860; Med.-Chir. Transactions, vol. xliii.
[7] British Medical Journal, Oct. 17, 1857.
[8] Am. Journal of the Med. Sciences, May, 1847.

Phenomena and Symptoms of Fracture.

When a bone is broken, it loses more or less completely its value as a lever, and the muscles of the part, instead of acting upon it as a whole, act upon the fragments separately. The periosteum is torn, or, in rare cases, stretched. The surrounding soft parts, including capillary and other vessels and nerve fibres, are ruptured and lacerated to a greater or less degree, and pressed upon by the ends, jagged or pointed, of the fragments. Hence, the injury gives rise to a series of phenomena, or symptoms, which are now to be described.

Sound.—Occasionally, but very rarely, the patient hears a distinct *sound* attending the giving way of a bone; and sometimes it is even perceived by the bystanders. But under the circumstances of excitement usually attending an accident, a momentary and unlooked-for noise may readily escape notice, even if it were one which would, if expected, be plainly audible.

Loss of Function.—Almost always there is immediate *loss of power* in the part where the fracture is situated. This does not mean that the muscles are paralyzed, although we often hear non-professional persons assert that an arm, for instance, cannot be broken, because the patient can move his fingers. But the value of the affected bone, as a lever, is destroyed; and hence the system of which it forms a part is useless.

When, however, there are two bones, only one of which is broken, or when the injured bone is braced by tissues around it, there is sometimes so little disability, for a time at least, as to cast doubt upon the reality of the fracture. Thus, Hunt[3] records the case of a man aged 26, struck by a falling girder, who walked next morning to a steam-train, got off at Philadelphia, and into a street-car at the station; from the car he walked with a stick some two hundred and fifty yards to the Pennsylvania Hospital gate, and thence up into the ward in the third story. He died on the twenty-third day, from pelvic abscess and pyæmia, and it was found that "the neck of the femur, immediately behind the head, was broken directly across, the line of fracture being immediately within the capsule of the joint."

In 1877, I saw an elderly lady who broke the neck of the femur by tripping in the carpet, and who yet walked up and down a flight of stairs several times a day during the following week. She died exhausted about two weeks subsequently, and there was found extensive fracture of the bone referred to.

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[1] Op. cit., vol. i. p. 255.

[2] The reader, should he wish to pursue this subject further, will find valuable information in Bouchut's Traité Pratique des Maladies des Nouveaux-Nés, etc., Paris; also, in Delore's article on Fractures in the Fœtus, in the Dictionnaire Encyclopédique des Sciences Médicales; in Kuestner, Die typischen Verletzungen des Extrem.-knochen des Kindes durch den Gebürtshelfen, Halle, 1877. He may also consult with advantage an article by Dr. Alex. Russell Simpson, "On Diastases in the Bones of the Lower Extremity of the Fœtus, produced by the Accoucheur," in the Edinburgh Med. Journal for June, 1880; and one by Ruge, in the Zeitschrift für Gebürtsh. und Frauenkrankheiten, Berlin, 1876.

[3] Philadelphia Medical Times, Oct. 26, 1872.

In 1876, one of my own children had his arm broken by an accidental blow; there was no displacement, and no sign of fracture except pain and loss of power, until two weeks later, when he had a fall, and the fragments at once became freely movable.

DEFORMITY of the affected part is almost always one of the results of fracture; not invariably, because it may be that the periosteum remains sufficiently intact to hold the fragments in place. The kind and degree of deformity vary greatly in different bones, and in different portions of the same bone; it is apt to be less where the fracturing force has not been very violent, where only one of two parallel bones is broken, and where the bone, if single, is surrounded by a large mass of muscle.

Deformity may be owing either to the original violence, to muscular contraction, to the weight of the distal part of the limb, or to incidental causes, such as, in case of the femur, the pressure of the bed-clothes on the foot. When the fracturing violence is direct, it simply forces the fragments apart after breaking them; and they may be held thus by the entanglement of their serrations, by muscular contraction, or by both combined; when it is indirect, the leverage afforded by one or both fragments will be readily understood. Muscular contraction may drag the fragments apart, as in the case of the patella or olecranon; or may pull one fragment past the other, as when the shaft of the femur is broken obliquely; or may rotate one fragment, as in fracture of the cervix femoris. In case of fracture of the thigh or leg, the slight weight of the foot, perhaps with the addition of that of the bed-clothes, is sufficient, acting through a long bent lever, such as is formed by the distal part of the limb, to produce great twisting.

We often meet with expressions such as "the fragments being uncontrolled," and "the fragments assuming bad positions;" but these are incorrect, as they imply that the fragments are not, as they really are, absolutely passive. It is not generally at the seat of injury that we must look for the causes of deformity or of its continuance.

However produced, deformity consists in a change in the relation of the axes of the fragments. This change may consist either in their forming an angle with each other—angular deformity; or in the rotation of the distal one—rotary deformity; or in the end of one passing by the end of the other—lateral deformity, over-riding, over-lapping, or shortening. Obviously these may all be presented together in fracture of a long bone—the femur, for example—or they may exist singly. And either of them may, in either case, be very slight or very pronounced; but their significance does not depend upon their degree.

Of all the phenomena attending fractures, the deformity is the most important, not as much on account of appearances (although in women this may sometimes be a matter of great moment), as by reason of the disability which it is apt to involve if it is uncorrected. Even a slight degree of angular or rotary displacement may, in the upper extremity, interfere seriously with the complicated movements upon which the free use of the hand depends, or, in the lower extremity, may give rise to awkward lameness. Hence the great end and aim of the innumerable appliances which have been, constantly are, and probably will always continue to be, proposed for the treatment of fractures, is the keeping of the fragments in their normal relation until they have become fixed thus by the process of repair.

The degree of the deformity is not always, or indeed generally, an index of the difficulty of its correction; for often a very slight displacement can scarcely be overcome, while it may be that a very great one will yield at once. But, on the other hand, deformity which is easily corrected is apt to be reproduced with equal readiness, and under such circumstances all the resources of the surgeon may be taxed to keep the fragments in proper place.

A point which should always be borne in mind, is that the pain suffered by the patient may be very slight, although the bones are in very bad position. Hence the surgeon should by no means be satisfied that all is going on well because no complaint is made. Nothing but actual inspection of the injured part can assure him of its safety. This remark, however, does not apply to fractures of the ribs, or to such other fractures as are serious only because of the involvement of contained viscera.

PAIN is an almost invariable attendant upon fracture. It is due in part to the tearing of the soft parts, and to the inflammatory condition immediately set up thereby; in part to the irritation of the soft parts by the ends of the fragments; and perhaps in part to the sensitiveness of the fragments themselves, or at least of the medulla. A peculiar, thrilling, numb pain, extending down along the limb to the fingers, is often complained of in fracture of the arm, from pressure of the lower end of the upper fragment against the nerve-trunks; and occasionally, but much more rarely, an analogous pain accompanies fracture of the leg.

I have once or twice seen cases in which the persistent pain was out of all proportion to the severity of the injury, in persons of very sensitive nervous systems, and liable previously to attacks of neuralgia; but generally the pain is not very violent, and subsides steadily with the reduction of inflammation. It is only apt to remain, under proper treatment, when the fracture is in a part such as the lower third of the forearm, where there are extensive thecal serous membranes; here there may be set up a sort of rheumatoid irritation, difficult to overcome, and productive of much suffering.

A notion prevails extensively among the laity that fractures are most painful when they are "knitting," and that the ninth day is the time when this process is at its acme; I need hardly say that this opinion is wholly without foundation in fact.

Persistent pain, or rather tenderness, over one part of a bone may become an important symptom in case of mere fissure.

MOBILITY.—A greater or less degree of *mobility* at the seat of fracture is nearly always observable, and is more distinct the nearer the lesion is to the middle of a long bone. Of course the mobility referred to is passive, and may be detected either upon an attempt of the patient to use the part, or by grasping the two portions of the limb, one in each hand, and then placing them at an angle with one another, or rotating them in contrary directions. It is upon this mobility that the loss of power after fractures is chiefly dependent.

CREPITUS.—Along with the mobility, if the ends of the fragments be in contact, there is developed a peculiar, rough, crackling or clicking sound, partly heard and partly felt, known as *crepitus* or *crepitation*. It is not always equally distinct, being sometimes masked, either by effusion of liquid or by the entanglement of soft parts between the fragments, sometimes lessened by impaction. It is not present, for obvious reasons, in incomplete fractures. *Bony crepitus* should be carefully distinguished from what is known as *soft crepitus*—the crackling of dry tendon-sheaths—and from a very similar but smoother sound due to the rubbing of the dislocated head of a bone over the surface of another bone covered by periosteum. When clearly heard and felt, true crepitus is proof positive of fracture. Yet it does not always indicate accurately the degree of mobility. It may be quite loud, and give the impression of loose grating, and yet the fragments may be closely held together. I recently saw an instance of this in an old lady of eighty-five, who died some weeks after sustaining a fracture of the cervix femoris; during life and after death, the crepitus was so distinct as to lead to the belief that the fragments were very movable, yet, when the bone was removed they were found in accurate apposition, and hardly any sound could be elicited.

Crepitus is of course wanting when the fragments are not in contact, as in fractures of the patella and olecranon, if one portion of the bone is drawn up so as to leave a wide gap, and in some cases of overlapping.

I feel constrained here to enter a protest against the employment of undue efforts to obtain crepitus. Should it not be readily felt, the surgeon should fall back upon the other means of diagnosis; as by persisting in the attempt to move the fragments upon one another, he not only gives present pain to the patient, but may do harm by producing or increasing displacement. When once the surgeon in charge has perceived it, he ought not to unnecessarily elicit it, again and again, as I have sometimes seen done, to satisfy either himself or others.

SWELLING is very apt to follow upon the occurrence of fracture, especially in superficial bones, and in the neighborhood of joints. It is due to inflammatory effusion, and takes place very rapidly, sometimes almost immediately.

ECCHYMOSIS nearly always shows itself in the vicinity of a fracture, and is often owing to the rupture of small vessels in the soft parts, just as in any other bruise. But when a bone is broken, its vascular medulla is torn across; and hence there comes on gradually an extravasation of blood, sometimes staining the skin a deep mottled purple, almost black, and extending along the limb for a great distance. This secondary effusion of blood is much more significant than that which shows itself within the first few hours after the injury. It is usually very slowly absorbed, and may often be still perceptible as a green and yellow discoloration, even after the fracture has been altogether repaired.

At the same time with this extravasation, there may appear upon the surface of the skin, especially in weakly patients, *blebs* or *bullæ* of various size, sometimes very large, distended with serum more or less stained with blood. These are often a source of great alarm to the patient, and even to the inexperienced surgeon; but if carefully let alone, they will shrink away in time, and the cuticle either becomes re-attached, or a new cuticle forms before the old one is cast off. It is a bad practice to open them, as they may then give rise to troublesome and intractable sores, interfering with the treatment of the fracture itself.

NUTRITIVE CHANGES.—Certain local, atrophic changes have been observed in cases of fracture, and may be mentioned among the phenomena attending injuries of this class, although they are by no means constant. Curling[1] speaks of *atrophy of one fragment* as not uncommon, and gives a list of twenty-four specimens illustrating this condition, which, however, is certainly not often present in such a degree as to attract attention. Guenther[2] claimed that the *growth of the nails* on the affected limb was arrested during the process of union; but his observation has not been substantiated by the experience of others. I have myself reported[3] two cases, one in the leg and one in the ring-finger, in which the nails did not grow on the injured members; but, in spite of careful watching for other similar cases, I have failed to meet with them. *Muscular wasting*, from confinement and disease, is very frequently seen in fractured limbs; but in general it speedily disappears upon the resumption of the normal functions of the part, as does also the œdema which often accompanies it.

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[1] Med.-Chir. Transactions, vol. xx.

[2] Gazette des Hôpitaux, Nov. 24, 1842. (Malgaigne.)

[3] Am. Journal of the Med. Sciences, April, 1874.

From what has now been said of the general phenomena attending fractures, the symptoms may be readily learned. These are divided into two classes,—the *rational*, and the *physical* or *sensible*.

The former are such as give rise to a reasonable suspicion of the existence of fracture; they are pain, loss of power, swelling, and ecchymosis. To these may be added, when it is present, the audible crack caused by the snapping of the bone; but this would not be conclusive, because very much the same sound might accompany the rupture of tendon, muscle, or ligament.

The physical or sensible signs are conclusive: deformity, preternatural mobility, and crepitus. Sometimes the first named, striking the eye of the surgeon, will at once reveal the nature of the case. But for the most part it is from the combination of all that he is enabled to frame his opinion.

CONSTITUTIONAL SYMPTOMS ACCOMPANYING FRACTURE.

Perhaps it will have been noticed that nothing has as yet been said about the *constitutional symptoms* attending fracture. In very many cases these are very slight, and might readily be overlooked by an inattentive observer. Yet they always occur, and are in proportion to the severity of the local injury; modified, however, by the idiosyncrasies of the patients, by their condition at the time of sustaining the hurt, and by incidental circumstances. Thus, in some individuals, the nervous system is very sensitive, and even a simple fracture, produced by slight violence, may give rise to marked *shock*. Such shock may be the more severe from the fact of previous fatigue, of fright at the time of the accident, or from other transient circumstances. Wagstaffe,[1] in an article on temperature in shock, in surgical cases, notes a decided lowering as attendant upon compound fractures; and it is probable that a proportionate degree of reduction would be detected in less serious cases by careful observation.

Following upon this state of depression, a more or less decided *febrile rise* is often noted, especially in private practice, where patients are apt to demand and receive more attention than in hospitals. But Stickler[2] has proved, by a series of carefully tabulated observations, that there is, as a rule, a temporary febrile rise after fractures; it reaches its maximum during the first three days, when the local inflammation is at its height.

Upon the subsidence of this febrile movement, the system at large generally ceases to manifest any disturbance, and the whole period of local repair may be passed through without any other trouble than perhaps constipation, and it may be indigestion, if the patient is prevented from taking exercise, and yet indulges his appetite. But in old and feeble persons, the powers may be unequal to the tax upon them, and a condition of *debility* may ensue, from which recovery is impossible. I have seen a simple fracture of the humerus prove fatal on the seventh day, in a lady of eighty-one; yet Henderson[3] has recorded the case of a woman, eighty-nine years old, whose femur, broken near the middle, was found firmly united on the forty-fourth day; Meachem[1] one, in which, in a woman of ninety, a fracture of the lower third of the leg was united in twenty-eight days; and Lee[2] one of union of a fractured femur in a man of ninety-eight. These cases are exceptional, and do not set aside the fact that old age makes every injury more formidable.

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[1] St. Thomas's Hosp. Reports, 1870.

[2] New York Med. Record, Feb. 11, 1882.

[3] London Med. Gazette, Jan. 13, 1843.

Diagnosis of Fracture.

This matter has, of course, been to a certain degree dealt with in speaking of the symptoms of these injuries, and it must be considered again in reference to each special fracture; but there are some general points which may be made here, and some rules laid down, in order to save repetition.

The earlier an examination can be made to determine whether or not fracture exist, and its seat, if present, the better; since swelling often comes on very rapidly, and the muscles become rigid, so as to mask the condition of the bone. Hence, if the surgeon be called to a patient who must be moved a long distance to his home, or to a hospital, he should, if possible, ascertain at once the character of the injury, by as careful an examination as the circumstances will allow.

In cases of injury in the neighborhood of joints, this rule is especially imperative; since here the question is apt to be between fracture and luxation, and, if the latter be overlooked, the delay involved may add seriously to the difficulty of reduction. Of mistakes of this kind, instances will be given hereafter.

As a general rule, in the comparison of fractures and luxations, it will be found that, in the former class of injuries, the degree of possible passive motion is increased beyond the normal, while in the latter it is, in certain directions at least, materially diminished. On the other hand, in luxation, the power of moving the limb to some extent is apt to be retained, the lever affected not being broken, but having merely changed its bearing point; while in fractures, as before stated, the limb is usually altogether disabled.

From the study of normal anatomy certain *test lines* have been derived, by which the displacement consequent upon fractures, as well as luxations, may be detected. With these lines, and with the relation of the normal skeleton to them, the surgeon ought to render himself perfectly familiar, so that they may serve as landmarks in his examination of injured parts. They will be detailed in speaking of fractures in the several regions.

The diagnosis of fracture has reference not merely to its existence, but also to its exact seat and direction. The latter points are, indeed, in many cases by far the most difficult to determine, and may have to be arrived at by exclusion only. The general symptoms already detailed may be clear enough, and the fact of fracture be absolutely established, yet the surgeon may be in doubt as to the precise line of breakage, or even, when a joint is involved, as to which of the bones entering into it has suffered. These questions can only be settled by careful exploration, with a skill acquired by experience; in other words, with the educated hand. Occasionally, the observation of the effect of certain passive motions will go far to solve the doubt; or gentle and dexterous pressure with the tips of the fingers, perhaps with the nail, may reveal the line of breakage.

In the *diagnosis of compound fracture*, as to its extent and severity, the finger is always better than any other probe; but even this should be used with caution, and only for the purpose of determining such points as the surgeon really needs to know. All poking about to satisfy mere curiosity, at the risk of disturbing or tearing tissues not already damaged, and all wrenching of the fragments to get at the deeper parts of the wound, should be abstained from. The amount of injury to vessels and nerves can be better ascertained in other ways, and may be increased by meddlesome and indiscreet handling.

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[1] Am. Med. Times, 1861.

[2] St. George's Hospital Reports, vol. iv. 1869.

Consequences of Fracture.

While it is quite true that, in general, simple fractures progress steadily toward recovery, it is also true that they sometimes give rise to very grave and even fatal symptoms. These symptoms may be general or local, immediate or remote. Murray[1] mentions a case in which a simple comminuted fracture of the thigh was followed by *traumatic delirium;* Hammick,[2] one in which *tetanus* ensued upon simple fracture of the thigh. *Pyæmia*, not a very uncommon sequence of compound fracture, has been seen by Hewett[3] as the result of simple fracture of the leg.

The occurrence of *wounds of arteries*, *veins*, *and nerves*, has been already mentioned (*complicated fractures*), and will be again referred to in connection with fractures of special bones. Occasionally, when vessels of some size are injured, *gangrene* comes on, or the *hemorrhage* challenges immediate attention, and either ligation or amputation must be performed; but sometimes the symptoms are only perceived at a later period, when *aneurism*, true or false, has developed itself.[4] With regard to *nerves* also, the signs of the lesion may appear immediately, or may be postponed until they show themselves in the altered nutrition or sensation of the distal parts. In several instances to be hereafter quoted, it was to the callus that the trouble was to be attributed, either from exuberance of this formation, or from entanglement of nerve-trunks within it. Nerves may also be caught and pinched between the fragments; a case is mentioned by Callender[5] in which the ulnar nerve was thus entangled in a fracture separating the styloid process and triangular ligament from the rest of the ulna. The same author saw a case in which a compound fracture at the wrist was followed by gangrene by reason of stretching of the ulnar and median nerves.

Pre-existing disease may become fatal when complicated with fracture; thus Hunt[6] has placed upon record a case in which a man, aged 29, who from the age of four years had had chorea and partial hemiplegia, lost his life from the incessant movement of his arm, broken by an accident.

There are some instances in which untoward results take place without any apparent reason. In one of his clinical lectures, Prof. Verneuil referred to the case of a man, 60 years of age, strong, robust, and tall, who had been in hospital for two months and a half for a fracture of both bones of the leg. He was treated as usual, had exhibited no bad symptoms whatever, and, in fact, was just about to be sent to a convalescent hospital prior to dismissal, when (the only thing that had excited attention having been some alteration in his features) he suddenly died, his face having a violaceous aspect. Prof. Verneuil believed that this must have occurred from *embolism*, which is not very rare after fracture. It is produced by *thrombosis* of some of the veins in the vicinity of the fractured bone, which is the cause of the œdema that so commonly accompanies fracture of the leg. Through a sudden movement or muscular effort, one of the clots which have thus formed in the inferior veins, and which are not usually very adherent, may become detached, and, entering the femoral and iliac veins, and eventually reaching and obstructing one or more of the branches of the pulmonary artery, may give rise to sudden death, as in asphyxia. However, in this case the diagnosis was erroneous, for the most careful examination of all the veins and of the pulmonary arteries failed to show the existence of any clot. The heart was absolutely empty, and the brain, minutely examined, exhibited no disease.[1] Again, Hammick[2] describes the case of a man with simple fracture of the leg, who was very despondent; on the third morning he "became ill, grew very feeble, and in four hours was dead. We examined with the minutest dissection every part of the body, but were not able to detect anything in the remotest degree to account for his death." It seems not improbable that this may have been an instance of *fat embolism.*

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[1] Edinb. Med. Journ., Feb. 1882.

[2] On Amputations, Fractures, etc., p. 74.

[3] Lancet, 1867, vol. i. p. 628.

[4] For much valuable information on this subject, with details of 27 cases, the reader is referred to a pamphlet entitled "Des Anévrysmes compliquant les Fractures. Par Gérard Laurent, Docteur en Médecine, etc." Paris, 1875.

[5] St. Bartholomew's Hosp. Reports, 1870.

[6] Pennsylvania Hosp. Reports, vol. ii. 1869.

THROMBOSIS AND EMBOLISM.—These sometimes ensue upon the breaking of a bone. Southam[3] has recorded two cases, one in a man aged 60, with Pott's fracture of the fibula, in whom thrombosis appeared on the 17th day, and proved fatal, and the other in a woman aged 65, also with fracture of the fibula, who had like symptoms on the 16th day, and died. In the former case the diagnosis was verified by an autopsy. A case is reported by Tyrrell,[4] in which a man aged 49, had his left leg fractured for the sixth time, the other leg having been broken once. On the twelfth day he had symptoms of cerebral disturbance, followed by partial paralysis of motion on the left side of the face and in the left arm. These symptoms were ascribed by Tyrrell to the withdrawal of his accustomed stimulus, but should rather, perhaps, be referred to embolism.

FAT-EMBOLISM[5] is a condition first observed as a sequence of fracture by Wagner and Zenker, in 1862. It consists essentially in the passage into the veins of liquefied fat, which is carried into the lungs, brain, and spinal cord, blocking up the capillaries of those organs.

The occurrence of free oil in the blood had been pointed out by R. W. Smith, as early as 1836;[6] and in 1856 a case was reported by Macgibbon,[7] in which a woman, aged 35, affected with delirum tremens, died suddenly, the immediate symptoms having been dyspnœa, with coma and marked pallor; the autopsy disclosed fatty degeneration of the heart and other organs, and a great deal of free oil in the blood. Wagner, in 1865, Busch, in 1866, Bergmann, in 1873,[8] and Czerny, in 1875,[9] made important investigations on the subject, which has been further studied by Scriba.[10] Flournoy, in 1878,[11] showed that three conditions were needful for the development of fatty embolism after fractures: large openings in the veins; free fluid fat; and a *vis*

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[1] Med. Times and Gaz., Oct. 22, 1881, p. 486; from Gaz. des Hôpitaux, No. 86.

[2] Op. cit., p. 74.

[3] Lancet, March 1, 1879.

[4] St. Thomas's Hospital Reports, vol. i. 1836.

[5] See also the article on Shock, Vol. II. p. 374.

[6] Stokes, The Diseases of the Heart and the Aorta, p. 308. Dublin, 1854.

[7] Am. Journal of the Med. Sciences, Jan. 1856.

[8] Berliner klin. Wochenschr., Aug. 18, 1873.

[9] Ibid., Nov. 1 und 8, 1875.

[10] See London Med. Record, Oct. 22, 1873; Med. Times and Gazette, Jan. 8, 1876, and British Med. Journal, May 22, 1880. These articles were reproduced in the Am. Journal of the Med. Sciences, Jan. 1874, and July, 1880.

[11] Contrib. à l'étude de l'embolie graisseuse. Strasbourg, 1878.

a tergo, generally found in a copious extravasation of blood. Drs. Saundby and Barling, in a recent article,[1] quote papers by Boettcher and D. J. Hamilton, in 1877, Déjérine, in 1878–9, Duret, Sinclair, and Jolly, in 1879, and Mansell-Moullin, in 1881. Déjérine is said to have seen ten cases, and to have produced fat-embolism experimentally upon animals by means of sponge-tents or laminaria-tents introduced into the bones. Sinclair is quoted as authority for the statement that fatty embola were found in 10 per cent. of the bodies examined at the Pathological Institute at Strasbourg; but it should be remembered that post-mortem clots containing fat-globules may readily be mistaken for true fatty embola. The former have been repeatedly met with in autopsies upon diabetics with "milky blood."

Symptoms of Fat-embolism.—From the accounts given by Scriba and others, who have had opportunities of studying this subject clinically, it would seem that fat-embolism comes on as a sort of secondary shock, within two or three days of the receipt of the fracture, and therefore earlier than venous thrombosis usually appears. Its onset is marked by transient attacks of dyspnœa, with irregular action of the heart, slight hæmoptysis, and at first shallow respiration, at times interrupted by deep sighing inspirations; subsequently the peculiar form of breathing known as "Cheyne-Stokes" respiration,[2] manifests itself. Collapse, with marked pallor of the skin and mucous membranes, soon ensues; spasms of various kinds, or paralyses, generally bilateral, and diminution of reflex irritability, have been noted. The chest is free from dulness or râles. Fat has been detected occasionally in the urine. As to the temperature in this disorder, the accounts of observers vary. According to Scriba, it is lowered; but Skirving[3] records a case in which it was at first noted at 100°, but increased to 104°, and after death reached 105°. In another case seen by Saundby and Barling, in 1881, the temperature was 101.8°.

Secondary abscesses do not form in fat-embolism.

Czerny thinks that this condition is a constant attendant upon cases of fracture, but mostly in very slight degree, and without inducing any distinct symptoms. Minich[4] says that it occurs in all cases of fracture except in children, who are exempt from it by reason of the small amount of fat contained in their skeletons. Scriba is of opinion that it may go through several cycles, and that its injurious effect is due solely to the blocking of the vessels of the brain, since this was observed in all the fatal cases. Minich shares this view as to the cause of death; but it seems as if the interference with the function of the lungs must be at least contributory, if it has not a large share, in inducing the fatal result.

The *diagnosis* of this pathological condition can hardly be very obscure in any case in which the symptoms as described are well pronounced; and the prognosis, under such circumstances, must obviously be extremely grave.

As to the *treatment* of this affection, the intra-venous injection of sulphuric ether would seem to be clearly indicated; and diffusible stimulants might be given by the mouth. I am not aware, however, that any definite line of medication has yet been pointed out.

STIFFENING OF NEIGHBORING JOINTS is a very common sequence of fractures, and may be attributed to various causes. In some cases, violence is inflicted upon the joints as well as upon the bone at the time of the accident, and arthritis is set up, with effusion into the periarticular tissues. Or the circulation in the limb or its innervation, may be disturbed, so that the nutrition of all the tissues is impaired, and the movement of the joints is thus interfered with. By some authors, the long-continued immobilization of the joints required by treatment is thought to render them stiff; but this idea is rendered untenable by the fact that experience in other cases gives no such result; and it is more likely that ill-advised pressure by apparatus, or the inflammatory condition above alluded to, is at fault. As a general rule, this stiffening is only transient, and either gradually disappears with use, or yields to proper local medication.

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[1] Journal of Anat. and Physiology, July, 1882.

[2] "It consists in the occurrence of a series of inspirations increasing to a maximum, and then declining in force and length, until a state of apparent apnœa is established. In this condition the patient may remain for such a length of time as to make his attendants believe that he is dead, when a low inspiration, followed by one more decided, marks the commencement of a new ascending and then descending series of inspirations." (Stokes, op. cit., p. 324.)

[3] Lancet, Oct. 7, 1882.

[4] Lo Sperimentale, Marzo ed Aprile, 1882 (quoted in Medical News, Nov. 11).

ATROPHY of a broken limb sometimes takes place, and may affect all its tissues, or the bone only. A very curious instance of the latter kind is recorded by Drs. Jackson and Dwight,[1] in which a humerus, broken for the second time, was almost wholly absorbed; and another by Gross,[2] in which the fracture was originally double. In both these cases the arm retained very considerable muscular power.

When all the tissues of the limb are atrophied, the bone also may shrink, but this is not apt to be the case. The muscles become small, stiff, and weak, and the foot or hand, as the case may be, contracted and twisted, much as in cases of paralysis from lesions of the central nervous system. "Pointed foot" is not unusually due to atrophic contraction of the muscles of the calf.

Prevention, it need hardly be said, is in these cases far better, and certainly far easier, than cure. Often, indeed, the latter proves to be impossible. The measures to be adopted are very simple, and their efficiency depends much upon the regularity and perseverance with which they are applied. Frictions, with or without medicated liniments, bathing, shampooing, or massage, and sometimes faradization, may occasionally restore the tone of muscles which seemed at first hopelessly damaged. But no discreet surgeon will venture in a case of this kind to hold out hopes which may utterly fail to be realized.

NECROSIS, after simple fracture, is extremely rare, if it ever occur at all. Possibly in some of the cases in which blows or other injuries are followed by the death of a portion of the bone, there has really been a separation of the part thus mortified; but I have never seen an instance in which this could be proved.

After compound fractures, however, it is very common to find one or more splinters loosened and dead; their presence may interfere with the process of union, which is apt to take place promptly upon their removal.

DEVELOPMENT OF MORBID GROWTHS.—Among the remoter local consequences of fracture may be mentioned the development of tumors at the seat of the old injury. Virchow,[3] after stating that enchondroma, more frequently than any other tumor, is clearly to be ascribed to traumatic causes, says:—

> "Among these, fractures seem to be of great interest. Nélaton (Gaz. des Hôp., 1855) mentions a man who, having broken his leg, was completely cured in two months; but six months afterward had severe attacks of pain in the part. Re-fracture occurred from slight violence, and union again took place in two months, but the part remained painful. A tumor began to develop itself, increased more and more, and at length

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[1] Boston Med. and Surg. Journal, July, 1838, and Oct. 10, 1872.

[2] Op. cit., vol. i. p. 929.

[3] Die krankhaften Geschwülste, Band i. S. 482.

burst. The patient died exhausted five years from the date of the first fracture; the autopsy disclosed an enchondroma. Otto (Seltene Beobachtungen zur Anatomie, etc.) speaks of a woman who, two years before her death, sustained a fracture of the humerus, which united, but remained painful and became greatly misshapen; there was developed a tumor (clearly an osteoid chondroma) which acquired a colossal size. Ducluzeau (Lebert, Traité d'Anat. Pathol.) removed from the rib of a man an enchondroma, which had taken its origin from a fracture of the bone several years previously. Langenbeck (Deutsche Klinik, 1860) disarticulated the shoulder of a man aged 23, on account of a tumor which I recognized as an osteoid chondroma, and which began a year and a half after a fracture caused by a fall."

Adams[1] has recorded the history of a man who twenty-five years before his death broke his humerus; nineteen years afterward he strained it, and it remained weak; four years after this a swelling was perceived, which grew rapidly, so that amputation was thought of, but declined. The tumor ulcerated and discharged a glairy fluid; at the time of death its circumference was equal to that of the body. It was composed of enchondromatous, colloid, and compound cystic elements.

It is perhaps scarcely proper to include among the cases now under consideration those in which, fracture occurring in a person already affected with malignant tumor, the constitutional disease manifests itself afresh at the point of local injury. Here the fracture merely serves as a nucleus, as it were, around which deposit takes place, precisely as may be observed in other cases of hurts. Sometimes, indeed, it may be questioned whether the bone may not give way because its texture is already impaired by the development of disease; as in one instance recorded by Morton,[2] in which the woman having already a mammary tumor, the left humerus gave way as she turned in bed, and "shortly afterwards the tumor was noticed at the seat of fracture;" death occurred within three months.

The symptoms and diagnosis in these cases need hardly be discussed, and the prognosis is unfortunately but too clear. As to treatment, it must be based upon general principles; often there is no chance for anything but palliative measures. Amputation may sometimes save suffering, and delay the fatal issue.[3]

General Prognosis of Fractures.

Various circumstances must be taken into the account in forming a prognosis in any case of fracture. Among these are: the character and amount of the injury to the bone, its simple or compound character, its extent, the presence or absence of comminution, the nearness of the lesion to a joint, the amount of damage done to the soft parts. The age and previous history of the patient are also to be regarded. From a consideration of all these points, some idea may be formed as to the chances of saving the patient's life, as well as of preserving a useful and sightly limb.

With regard to the influence of the local conditions of the injury on the prognosis of fractures, it scarcely needs to be enlarged upon here, as it has been already set forth in the discussion of the phenomena and varieties of those injuries. As to age, it may be said that the fractures of children generally unite with great readiness, and that the ultimate result is apt to be the complete restoration of the shape and functions of the limb, although an exception must be made in the case of epiphyseal disjunctions and fractures near the elbow-joint. In adults, the chance of permanent deformity and of stiffening of the joints is greater, and in old persons it is very apt to occur. Some of the fractures to which old people are liable, and especially those of the cervix femoris, are almost sure to end in non-union and lameness, if not total disability, for the remainder of life.

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[1] Trans. of Pathol. Society of London, vol. i. p. 344.

[2] Supplement to Catalogue of Penna. Hosp. Museum, p. 19.

[3] The reader may consult with advantage: Tausch, Zur Casuistik der vom Callus geheilten Frakturen sich entwickelnden Geschwülste. Halle, 1881.

Of fractures of certain bones—the patella, and the olecranon and coronoid processes of the ulna—the result is, as a rule, union by fibrous tissue only, and the necessity of advising the patient of this fact beforehand must be quite obvious. In all cases the surgeon should insist most positively upon obedience to his directions, and should remember that if he is lax in this respect, any damage resulting from the waywardness of the patient will be laid at his door.

It is better always to give a guarded prognosis even in simple cases, as may be inferred from what has been said in previous pages as to the occasional occurrence of unexpectedly serious symptoms. And even in the matter of time, a prudent surgeon will be slow to make promises which he may not be able to fulfil. For example, if a man with a broken leg is assured that he will be able to walk in six weeks, he will be very much dissatisfied if a cure is not effected in less than two months. And if a man with a fractured femur is told that he will be able to walk as well as ever, he will naturally be disappointed if he finds himself with a shortening which involves a permanent limp in his gait.

Repair of Fractures.

Although the process of repair of broken bones has been the subject of study and discussion by many of the ablest surgical observers and writers, it is not as yet thoroughly understood, many points remaining unsettled. I shall try to give such a practical summary of what is known in regard to it as may accord with the limits of the present article, referring the reader who desires further information to the admirable description given by Paget,[1] and to the more recent works of Cornil and Ranvier,[2] and of Billroth.[3] In Todd and Bowman's Cyclopædia of Anatomy and Physiology,[4] there is an excellent exposition of the opinions advanced up to the date of its publication (1836), by Dr. W. H. Porter; and Virchow[5] has presented a very interesting account of the result of his own researches.

This subject may be studied in various ways. By careful observation of clinical cases, the general phenomena are learned, and further explained by the opportunities afforded of dissecting the parts in patients dying at different periods after the receipt of these injuries. Experimental fractures produced on animals may be examined with advantage, allowance being made for known differences between them and human beings. Microscopical investigations have thrown much light upon the modes of development of the reparative material.

When a bone is broken, some injury is always inflicted on the *periosteum.* Its fibres may be merely stretched, but more frequently they are torn across at the convexity of the angle formed by the fragments. At the same time, on the other side, where they are not ruptured, they are apt to be stripped up for a greater or less distance along the bone. Occasionally, when the fragments are violently forced apart, the periosteum may be completely severed; but even then, before it yields, it is probably loosened from the surface of the bone. Towards the broadened ends of the long bones, and in the thick and flat bones, this stripping up is less, and the complete severance of the periosteum is not apt to occur.

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[1] Lectures on Surgical Pathology, Lecture XI.

[2] A Manual of Pathological Histology. By V. Cornil and L. Ranvier. Translated from the French by Drs. Shakespeare and Simes. Philadelphia, 1880.

[3] General Surgical Pathology and Therapeutics. By Theodor Billroth. Translated from the German by Dr. Charles E. Hackley. New York, 1871.

[4] Art. "Bone, Pathological Conditions of." Op. cit., vol. i.

[5] Cellular Pathology. Chance's translation, 1860.

By the violence causing the fracture, the surrounding *soft parts*, as well as the *marrow*, are also lacerated, and an effusion of blood takes place at the seat of injury. This blood is derived chiefly, of course, from the more vascular of the tissues, and varies in amount in different cases. Immediately succeeding the infliction of the injury there is set up an inflammatory condition, which gradually subsides, and then the work of repair begins, perhaps in the majority of cases early in the second week.

This process of repair does not differ in any essential respect from that of wounds of the soft parts, except that the final result is the production of new bone, and hence that the lymph or plasma must undergo ossification, instead of conversion into ordinary cicatricial tissue.

Of the blood which was poured out from the vessels of the bone itself, of the marrow, and of the surrounding soft tissues, a portion, and perhaps a large part, is undoubtedly absorbed. But a part of it very probably remains and becomes organized, contributing to form the uniting medium.

This uniting medium, constituted by lymph or plasma derived from the tissues around the broken bone, from the bone itself, from the periosteum, and from the marrow, is called, as it begins to assume firmness, *callus*. Whatever may be the abundance of the material formed around the fracture, it becomes permanent only between the fragments; although there are some cases, to be hereafter mentioned, in which masses of this callus, deposited all about the seat of fracture in an aimless and capricious manner, become ossified, and are never gotten rid of. There may be a large production of lymph about both fragments; but the superfluous portion is as a general rule wholly absorbed, and the form of the bone as nearly as possible restored.

According to Paget, there may be an *immediate union* of a broken bone, as in the healing of wounds of the soft parts by "primary adhesion," without any uniting medium; the continuity of vessels and other textures being simply renewed. But this must be extremely rare, and I know of no cases on record in proof of its occurrence. In some instances, which would seem to be specially likely to present this immediate union, it certainly does not occur; as, for example, in fractures of the clavicle without displacement, the periosteum seeming to remain intact. Here there is always, after a few days, a very marked swelling, which hardens and is gradually absorbed, just as callus does in the majority of cases.

By some of the older authors it was laid down as a rule that the callus was deposited around the fragments, so as to form a wide, flat "ring" about them—a sort of splint—and within them, so as to make what was called the "pin." To the former was given also the name "provisional callus," as it was supposed to be merely temporary.

Paget, whose views have met with general acceptance, says:—

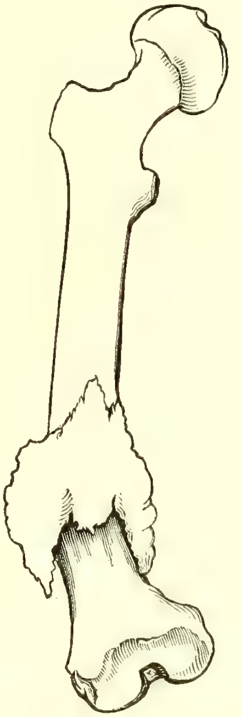
> "The normal mode of repair in the fractures of the human bones is that which is accomplished by 'intermediate callus.' The principal features of difference between it and that just described are: (1) that the reparative material or callus is placed chiefly or only between the fragments, not around them; (2) that, when ossified, it is not a provisional, but a permanent, bond of union for them; (3) that the part of it which is

external to the wall of the bone is not exclusively, or even as if with preference, placed between the bone and the periosteum, but rather in the tissue of the periosteum, or indifferently either in it, beneath it, or external to it."

He, however, admits that in the ribs, and occasionally in the clavicle and humerus, an ensheathing callus may occur, in consequence of unrestrained movement of the fragments, just as it does, as a rule, in animals. Yet, even in the latter, the ultimate result may be a much more complete restoration of the normal form of the bone than would be expected. Mr. Crisp exhibited to the Pathological Society of London[1] a specimen of oblique fracture of the humerus of a gorilla, united without deformity; and stated that this was only one out of many, in animals and birds, in which union was as perfect and the limb as useful as if splints had been applied.

We occasionally meet with cases, as has been already said, of voluminous formation of callus, much beyond the needs of the mere reparative process. Such a deposit, about a fracture of the shaft of the femur, is represented in the annexed diagram (Fig. 585). But in by far the largest number of cases, upon the subsidence of the inflammatory swelling immediately following the fracture, there is left merely enough new material to bridge over the interval between the fragments (for if they are not in exact apposition there will be a triangular or wedge-shaped gap of greater or less size on either side), and thus restore as nearly as may be the normal shape of the bone.

Fig. 585.



Voluminous callus in fractured femur.

When the fragments are wholly separated and driven apart, and the periosteum torn entirely asunder—an occurrence which is very rare, even when the ends of the fragments overlap one another in a marked degree—each fragment may, like the end of the bone in a stump after amputation, become closed in by a rounded shell of compact bone. Such is the case in some instances of ununited fracture, as will be presently more particularly described. But often when the fragments are separated, there is still a bond between them in the shape of the bridge of periosteum before spoken of; and in the space defined by this bridge there will be developed a mass of callus which, becoming ossified, connects the two fragments permanently, and may even acquire the cancellous structure proper to the medullary cavity, as well as the compact wall, of the shaft of the normal bone.

I believe it may be stated, without any exception whatever, that the periosteum is thickened and swollen in the neighborhood of a fracture. By some writers, and especially by Ollier,[2] this membrane has been described as endowed with the power of promoting the formation of bone in adjacent plasma, and even in the soft tissues if transplanted among them. That it has such a power, exercised in the original development of the skeleton, cannot be doubted; and from the statements just made as to the usual condition of the periosteum in cases of fracture, and as to the relation of the callus to the broken ends, the inference is clear that the uniting material is formed under the osteogenetic influence of the periosteal membrane.

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[1] Transactions, vol. xxvii. 1876, p. 340.

[2] Traité Expérimentale et Clinique de la Régénération des Os, etc. Paris, 1867.

Marcy[1] quotes the statement of Ercolani that neither the periosteum nor the ends of the fractured bone are concerned in the formation of osseous callus, but that the periosteum is destroyed at the points where callus is formed. He thinks that the material for the callus is furnished from the blood of the lacerated vessels of the injured tissues, including those of the medulla and Haversian canals. In healed fractures, both in man and animals, he found definite evidence of atrophy of the ends of the fragments. And from his experiments on animals, he concludes: that the old periosteum at the point of injury becomes destroyed; and that the exudation from the parts surrounding the fracture is well developed as early as the sixth or eighth day, and covered with a new periosteum. By the osteogenetic action of this new membrane he thinks that the exuded cellular elements are transformed into bone. Hence Klein[2] observes:—

> "From the description of the appearances in the microscopical specimens as given in the paper, it appears that the formation of the osseous callus takes place in essentially the same manner as that described by Billroth, that is to say, the new bloodvessels and the cells of the soft callus, as well as the new periosteum—or rather its osteogenetic layer—it seems, are derived from the medullary tissue of the Haversian canals at the extremities of the fractured bone."

As to the mode in which the uniting material, the blastema, whencesoever derived, becomes bone, authorities have differed. Paget says:—

> "It may become, before ossifying, either fibrous or cartilaginous, or may assume a structure intermediate between these; and in either of these cases, ossification may ensue when the previous tissue is yet in a rudimental state, or may be delayed till the complete fibrous or cartilaginous structure is first achieved. . . . .
>
> "The new bone, through whatever mode it is formed, appears to acquire quickly its proper microscopic characters. Its corpuscles or lacunæ, being first of simple round or oval shape, and then becoming jagged at their edges, subsequently acquire their canals, which appear to be gradually hollowed out in the preformed bone, as minute channels communicating with one or more of the lacunæ. The laminated canals for bloodvessels are later formed. At first, all the new bone forms a minutely cancellous structure, which is light, spongy, soft, and succulent, with a reddish juice rather than marrow, and is altogether like fœtal bones in their first construction. But this gradually assimilates itself to the structure of the bones that it repairs; its outer portions assuming a compact laminated structure, and its inner or central portions acquiring wider cancellous spaces, and a more perfect medulla. It acquires, also, a defined periosteum, at first firm, thin, and distinctly lamellar, and gradually assuming toughness and compactness. But in regard to many of these later changes in the bonds of union of fractures, there are so many varieties in adaptation to the peculiarities of the cases, that no general account of them can be rendered."

Virchow's description of the formation of callus may also be quoted, as it gives in some respects a fuller idea of the process, and from a slightly different stand-point. He says:—

> "The pre-existence of cartilage is by no means necessary for the formation of bone; on the contrary, an osteoid substance is very frequently formed by a direct sclerosis in connective tissue, nay, ossification is thus really more easily effected than when it takes place in real cartilage. We see also by the history of the theories concerning callus, that the endeavor to show that it is always developed in the same way or out of the same substance (*e. g.*, extravasated blood, periosteum, medullary tissue, exuded fluids, etc.), has proved the greatest obstacle to the true perception of the real state of things,

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[1] Trans. of Amer. Med. Association, 1881, pp. 907 *et seq.*

[2] London Medical Record, Feb. 15, 1882.

and that all have really had right upon their side, inasmuch as new bone in fact builds itself up out of the most different materials. Unquestionably, when the case runs a very favorable course, that path is chosen in which the new formation can be most conveniently effected, and it is by far the most convenient way when the periosteum produces a very large portion of the whole. This takes place in the following manner: the periosteum grows dense toward the edges of the fracture, and there gradually swells up, the swelling being of such a nature that separate layers or strata can afterward be pretty clearly distinguished in it. These continually become thicker and more numerous, in consequence of the constant proliferation of the innermost parts of the periosteum, and of the formation, by means of a multiplication of their cellular elements, of new layers, which accumulate between the bone and the relatively still normal parts of the periosteum. These layers may become cartilage, but it is not necessary, nor yet the rule. For we find that, in the greater number of favorable cases of fracture, where cartilage is produced, not the whole mass of the periosteal callus is produced from cartilage, but a greater or less portion of it is always formed out of connective tissue. The layers of cartilage generally lie next to the bone, whilst the further we proceed outward, the less does the formation out of cartilage, and the more a direct transformation of connective tissue, prevail.

"The formation of bone is, however, by no means restricted to the limits of the periosteum—very commonly it extends beyond them in an outward direction, and often penetrates, in the form of spicula, nodules, and protuberances, to a very considerable depth into the neighboring soft parts. It is self-evident that in these cases we have by no means to deal with any proliferation of the periosteum in an outward direction, but that an ossifiable tissue arises out of the interstitial connective tissue of the neighboring parts. Of this it is very easy to convince one's self, because osseous spicula are found shooting up in the interstitial tissues of the neighboring muscles. In the preparation from the fractured ribs [previously shown], places are still to be found in the external parts, where fat has been included in the ossification. It cannot be said, therefore, that the formation of callus around fractured parts is altogether a periosteal formation."

Virchow then goes on to speak of a different mode of development of callus, "that, namely, which takes place in the midst of the bone *from the medullary tissue.*"

"At the moment when the bone in a case of fracture is shivered, a number of little medullary spaces are naturally opened. In the neighborhood of these, the still closed medullary spaces are seen nearly invariably, when matters take a regular course, to become filled with callus, new lamellæ of bone attaching themselves to the internal surface of the osseous trabeculæ which bound the spaces, just as in the ordinary growth of bone in thickness, the originally pumice-stone-like layers become compact by the deposition of concentric lamellæ. In this manner it happens, that after some time a larger or smaller new layer of bone is found, filling up the end of the medullary canal of each fragment so as to occasion its occlusion. This is a kind of new formation which has nothing in common with the former one, as far as their starting-points are concerned, but has its origin in quite another tissue, and is altogether different in its palpable result, inasmuch as it produces, within the confines of the old bone, a condensation of that portion of the marrow which lies in the immediate vicinity of the fracture. Even in cases where the ends of the bones perfectly coincide, an internal formation of bone such as I have described takes place in the medullary canal of each fragment, producing its occlusion.

"These two kinds are the usual and normal ones. Around the two fractured ends, the swelling takes place; in the interior, the condensation. Gradually—in proportion as the extravasated blood is absorbed—the new masses of tissue which have been developed between the broken ends draw nearer to one another, and round about the fracture there forms a bridge- or capsule-like communication by means of the ossification of the soft parts. There is, therefore, but little reason to ask whether the callus proceeds from free exuded or extravasated matter. No doubt an extravasation takes place in the first instance into the space between the fractured ends, but the extravasated blood is generally pretty completely reabsorbed, and it contributes comparatively but very little to the real formation of the subsequent uniting media."

Ranvier thinks that the new bone constituting callus is always, in simple fractures, developed through a cartilaginous stage, but this is at variance with the views of other observers.

Mr. J. Greig Smith has published[1] an interesting article on the histology of fracture repair in man, giving the results of the examination of a number of specimens at various stages of the process. He sums them up as follows:—

> "A plastic, parent tissue is provided partly by the swollen and inflamed pre-existing tissues, partly by organized inflammatory neoplasm. The ossific stimulus lays hold of this parent tissue and infects it with the first change toward ossification, viz., calcification. The calcifying process proceeds along numerous irregularly disposed lines through the parent tissue, modifying it before it finally completely invades it. This modification of matrix ahead of the line of calcification consists chiefly of a swelling of the intercellular substance, bringing about an occasional resemblance to ordinary hyaline cartilage. When the process is completed by the formation of an areolar calcified tissue containing variously modified embryonic substance in its meshes, we have the great mass of so-called bony callus. This callus material soon begins to undergo the further changes toward true ossification; namely, absorption of the calcified substance and development on these calcified lines of true lamellar bone by osteoblasts derived from outgrowing marrow or cambium layer of periosteum."

As to the individual tissues concerned, he thus summarizes:—

> "*Blood-clot.*—The greater part of the effused blood is absorbed and disappears. Some amount of blood-clot usually remains in certain positions to become organized. After organization, more or less perfect, it may either directly become a parent tissue for bony growth, or undergo a further transformation toward this end. Blood-clot organizes by preference in the exposed medullary canal and over the jagged ends of the broken bones. Where it forms the chief nidus for ossification, bony union is longest delayed.
>
> "*Periosteum.*—Periosteum contributes to fracture repair rather by virtue of its position as a fibrous tissue than through its ordinary function as a bone-producer. Periosteal callus is rather a calcifying cellulitis than an ossifying periostitis. Periosteum does not undergo very much change preparatory to calcification. The calcified periosteal trabeculæ are the least perfectly developed and the most unstable of all the areolar bony callus material. Shreds of periosteal fibre traversing embryonic inflammatory tissue contribute materially to the rapidity with which calcification is carried out.
>
> "*Tendon and Ligament.*—Where present, these tissues play an important part in the ossifying process. Sometimes undergoing calcification without exhibiting material change of structure, they frequently, however, are subjected to preparatory modifications which assimilate them in appearance to true cartilage, and thereafter behave in ossification as ordinary cartilage does. The presence of an abundance of ligamentous tissue should warn us of a possible overgrowth of uniting bone.
>
> "*Fibro-cartilage.*—White fibro-cartilage may become calcified without undergoing preliminary structural changes. The calcareous deposit is finely divided and dense; and the advent of the absorptive process is long delayed. As a temporary bond of union, it is, when once formed, the strongest of all.
>
> "New inflammatory tissue contributes to bony growth after it has been in varying degrees assimilated to the formed tissues in its neighborhood. Occasionally it assumes a resemblance in structure to hyaline cartilage."

After the callus has been deposited and ossified, and the bone has begun to acquire strength, there still remains the modelling process to be accomplished; in other words, projecting points, edges, or other roughnesses have to be removed by absorption, so as to restore as nearly as may be the normal form of the bone. This is brought about in the same way as in the case of a bone sawed through squarely in an amputation, which becomes in time rounded off by a shell of compact bone, usually thin, and backed up by lamellæ nearly as regular as those already described as seen in sections through the articular extremities. Sometimes the new wall is thick and almost ivory-like in density and hardness; but it is always present, so that the medullary cavity is invariably covered in. Probably there is in the first place a formation of new bone, which scarcely acquires its density and hardness before the absorption of the outer and irregular portions of the old bone begins. How long the modelling process lasts, cannot well be determined; but it is most likely that it always occupies more time than all the rest of the repair of the injury. Sometimes it is not completed for many months after the bone has in great measure resumed its function.

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[1] Journ. of Anatomy and Physiology, Jan. 1882.

Thus far reference has been made to the reparative process in cases of fracture of the shafts of the long bones. When the breakage extends into a joint, so as to involve the articular cartilage, we find that although the joint-cavity may have been seriously damaged, perhaps filled with blood, the ultimate result may be very good. The blood becomes absorbed, the secretion of synovia is restored, and the end of the bone may show no trace of the solution of its continuity beyond either a groove or a depression. For, perhaps owing to the absence of periosteum, callus is not thrown out at the portion of the fracture corresponding to the joint; and if the fragments can be kept in accurate apposition, there will be no such bulging of new material as exists around the fragments elsewhere.

The same may be said of fractures of the patella. Here, if the broken portions can be kept in contact, so as to become united by bone, this will be found on the anterior surface to be marked by a more or less distinct ridge, while posteriorly, or on the joint surface, there will be rather a depression, as if there had been material absorbed instead of deposited.

Like all the other processes of nature, and especially like all the other processes of repair, the healing of broken bones takes place in obedience to certain general laws; and although in the majority of cases the result thus provided for is good—is, indeed, the best attainable as far as nature is concerned—still instances occur in which these blind forces work harm. Thus, in the case of fractures near the joints, the deposit of new bone may be such as to hamper the movements of the limb most seriously. In fractures of the forearm, the callus of one bone may unite with that from the other, and the resulting osseous bridge may do away altogether with the possibility of the pronation and supination of the hand, rendering it almost, if not wholly, useless. Nature is wholly indifferent to the individual; and it is for the surgeon to watch and guide her reparative efforts in each instance.

Fractures of *cartilage* are sometimes met with, and are repaired by means of a copious deposit of material analogous to the callus of bone. In the "Wistar and Horner Museum" of the University of Pennsylvania, there is a specimen of fractures of the sixth, seventh, and eighth costal cartilages of the right side, each surrounded by a somewhat irregular bony ring. A very similar specimen is in the Mütter Museum of the Philadelphia College of Physicians. Paget thinks that this occurs only in the costal and laryngeal cartilages, which have a tendency to ossify in advanced life.

When an articular cartilage is involved in a fracture of the bone to which it belongs, it does not seem ever to be fully repaired; a groove lined by fibrous tissue always marks the line of injury.

The repair of *compound* differs from that of *simple* fractures, in the fact that suppuration is almost inevitable, and that granulations spring up about the injured and exposed bone, by the ossification of which union takes place. In point of actual damage to the bone, many compound fractures are less serious than many simple fractures. And as soon as, by the process of granulation or by adhesion, the soft parts have closed in over the bone, repair goes on as rapidly as if the fracture had been simple throughout. No law can be laid down as to a definite difference between simple and compound fractures, in the length of time required for their repair.

According to Cornil and Ranvier,[1] in compound fractures—

> "The changes occurring are identically the same as in osteitis; at all the irritated points of the surface of the solution of continuity, the marrow becomes embryonic, and undergoes changes similar to those of a simple osteitis. Under the periosteum, the new embryonic marrow soon forms osseous trabeculæ; five or six days after the accident they may be found. The Haversian canals opened by the fracture are enlarged through the absorption of the osseous substance limiting them; the vessels and marrow which they contain contribute to the formation of the granulation tissue. The marrow in the central medullary cavity undergoes the same modifications, although more slowly. Thus, over the whole surface of the solution of continuity, there are formed granulations which enlarge and by uniting together constitute an embryonic or inflammatory tissue, in the midst of which osseous trabeculæ are developed, as in the physiological method of ossification. The needle-like points of the old bone seem always to act as a base for the new osseous formation. Growing in every direction, uniting one with the other and with the opposite fragments, they limit the spaces filled with the embryonic marrow. These spaces are gradually narrowed by the addition of new osseous layers, and consolidation is brought about by a firm adhesion between the two fragments of bone."

It is very necessary to remark, that, while this distinction between the mode of union in simple and compound fractures is clearly to be discerned, the two processes are often combined in the same case. Thus, either from the very first or from a later period, the deeper portions of a broken bone may be entirely excluded from the air; and hence in these the repair goes on by the method described for simple fractures, by the ossification of lymph or plasma passing through a stage of more or less complete development of fibrous or cartilaginoid structure. At the same time, granulations are forming about the exposed portions of the injured bone, and here the uniting medium, the callus, will be the direct result of the ossification of those granulations. Cicatricial tissue will be developed for the repair of all the damage to which the air finds access, and will take on the structure of the parts united. At first the scar in the skin will be closely adherent to the new-formed reparative bone; indeed, it sometimes remains so permanently. But in many cases there is a gradual stretching of the intermediate layer, until a very good imitation of normal areolar tissue allows the cutaneous cicatrix to play freely over the bone even where the fracture existed. This, however, corresponds in time to the later stages of the modelling process.

Defects in the Process of Repair of Fractures.

In the vast majority of cases of fracture of the long bones, osseous union takes place in due course. As the surgeon from time to time, during the period of treatment, handles the limb, he finds the fragments less and less movable upon one another, until at last they do not yield at all, and the patient himself becomes able to exert some muscular power upon the restored bone. Clinical observation has determined pretty nearly the average period at which, under ordinary circumstances, consolidation may be looked for in the several portions of the skeleton; and in general we do so expect it. But cases are met with in which the fragments remain movable; and the conditions of this failure to unite are now to be considered.

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[1] Op. cit., p. 210.

These cases have been divided into those of delayed union, of dissolved union, of fibrous union, of complete separation of the fragments, and of pseudarthrosis or false-joint properly so called.

DELAYED UNION is by no means uncommon. Scarcely a year passes that I do not see one or more instances in my hospital wards, and I have repeatedly been consulted about such cases in the private practice of others. It is not always easy to assign a *cause* for the failure, which may occur under the best treatment, and in persons seemingly of good general health. Porter[1] speaks of having "seen two cases of fractured femur remain ununited at the end of five and six months, in the persons of fine and healthy young men, although the ends of the bones were kept in apposition, and in every other respect the treatment was correct." I have myself seen union delayed oftener in the leg than elsewhere, and in some of the instances the fracture has been extremely oblique; the patients have been for the most part male adults of the laboring class, of middle age; although one, in private practice, was a very young man in excellent circumstances, and rather remarkably robust.

Although more frequent in men, delayed union is met with in women also, and among its constitutional causes *pregnancy* has been assigned by some writers a prominent place; but against the cases adduced in proof of this view must be set a great many in which the cure has been rapid. One such occurred to me at the Episcopal Hospital, in 1871.[2] In like manner, the evidence is conflicting as to the influence of *syphilis*, of *cancer* (not affecting the bone itself), of *paralysis*, of *old age*, and of great *losses of blood;* as to all these, while there are instances on record of their apparent influence in retarding the union of fractures, there are enough in which they seemed to have no such effect, to make the matter at least doubtful. The reader will find these various cases detailed in the systematic works of Malgaigne, Gurlt, and others. Norris[3] has discussed the subject at great length and very instructively.

The influence of very long-continued *low diet*, and of the debility thus induced, in hindering the consolidation of fractures, is much more clearly proved. In two instances, one recorded by Thierry[4] and the other by Poncet,[5] the repair of fractures seemed to have been delayed by indulgence in *sexual intercourse*, and took place promptly on the withdrawal of the opportunity for such indulgence.

Among *local causes* of delayed union there are some which seem to be unquestionable. Wide *separation of the fractured ends*, by a bad position of the fragments, or by loss of substance, may have this effect. Here there is more to be done, and nature takes longer to do it. The wonder is that union is not in some of these cases totally prevented. Norris[6] says: "In the case of a boy aged 12, who came under my care in the Pennsylvania Hospital in 1837, two inches of the tibia was removed, notwithstanding which he was discharged cured in eleven weeks, with shortening of the limb of but half an inch, the space occupied by the removed bone being filled by a firm and even callus." When the fragments are widely separated, it is very hard to prevent some disturbance of their relative position; and this may be sufficient to pull upon the as yet fibrous uniting medium, and interfere with its ossification, though not enough to induce actual inflammation. In like manner, an *attempt*

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[1] Cyclopædia of Anatomy and Physiology, vol. i. p. 447.

[2] Philadelphia Medical Times, Feb. 1, 1872.

[3] Contributions to Practical Surgery, pp. 23 *et seq.* Philadelphia, 1873.

[4] L'Expérience, 4 Nov. 1841.

[5] Brit. Med. Journal, March 18, 1882.

[6] Op. cit., p. 42.

to use a broken limb before the callus has become firm, may so disturb the newly developed tissue as to postpone its ossification for a time.

At the present day scarcely any surgeon can be found who would make use of *wet dressings* to a fractured limb after the inflammatory stage; and hence the prolonged employment of such applications, as a cause of delayed union, need be only mentioned as a matter of history.

Tight bandaging, it is to be feared, is sometimes practised, especially by surgeons in the country, who cannot frequently visit their patients; yet it is all the more dangerous under such circumstances. That it may induce gangrene of the limb is well known; but when not sufficient for this, it may very probably so far interfere with the nutrition and innervation of the part as to delay the process of repair.

Occasionally the interposition *between the fragments* of a portion of muscle, of a separated splinter, or of a foreign body, may cause a long delay in union, or, unless either removed or absorbed, may wholly prevent it. A curious case is quoted by Norris,[1] "in which the fragments of a clavicle, separated to the extent of an inch by the subclavius muscle, were united together very solidly by two bridges of newly-formed bone, in the centre of which the muscle, *itself ossified*, was imprisoned."

Necrosis or other disease of one or both fragments may hinder consolidation, until by appropriate measures the disease has been set aside or the necrosed portions removed.

The *ligation of the main artery* of the limb, sometimes rendered necessary by a wound, has occasionally been thought to interfere with the union of a fracture by cutting off the vascular supply. But, in other instances, as in a case recorded by Mr. Bransby Cooper[2], the process of repair seems to take place quite as readily as under other circumstances.

As to the effect of *nerve injuries* upon the repair of fractures, there is a decided conflict of evidence. Thus Travers[3] gives the following case:—

> A man had his fourth and fifth lumbar vertebræ fractured and dislocated by the falling of a load of gravel upon his loins as he was working in a pit. At the same time the bones of his right leg and his left upper arm were fractured. These were adjusted and set; the lower limbs, bladder, and rectum were paralyzed immediately, but the loss of sensation was gradual, and both sensation and motion were partially restored before his death. He lived eight weeks, notwithstanding two attacks of peritonitis. At the end of five weeks the fractured arm was perfectly united; the bones of the leg were unchanged, and exhibited not the slightest advance toward union; but at the time of his death some thickening of the fractured ends had taken place, and the process of union seemed to be at length commencing.

On the other hand, Kusmin[4] found that, in animals experimented on by him, the callus was larger and harder on the side on which the nerves had been divided. This was still the case after four or five months. The process of ossification was more rapid, and the result was true bone. The bony formation in the cartilaginous callus occurred in the earlier stages as a metaplastic process. The first signs of ossification began in the coaptated fragments in the neighborhood of the outer periphery of the old bone, and under the periosteum, markedly earlier and to a greater extent when the nerves had been divided.

The amount of mobility at the seat of fracture, when the consolidation is hindered by any of the circumstances now mentioned, varies somewhat; but it is apt to be only slight, and its development by the surgeon's hands is attended with pain, which may be quite severe. The bone remains useless as a lever or as a means of support. A certain degree of œdema of the limb is often present; the skin is apt to be harsh, and the muscles of the part are flabby.

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[1] Op. cit., p. 48. [2] Lancet, Dec. 5, 1840. [3] Further Inquiry, etc., p. 436.

[4] Ueber den Einfluss der Nerven-durchschneidung auf die Callus-bildung bei Fracturen. Allg. Wiener Med. Zeitung, Nos. 33, 34, und 35, 1882.

It is probable that the callus is in all these cases formed as far as the fibrous or fibro-cartilaginous stage, and that the delay is simply in its ossification; but I know of no instance on record in which an opportunity has been afforded of determining the state of the parts by dissection.

Under appropriate treatment, to be hereafter detailed, the full development of the uniting medium is generally brought about, and a good result at length obtained.

DISSOLVED UNION is much more rare than the foregoing condition. Under this head are embraced cases in which, callus having formed, and the fragments having become solidly united, the reparative material softens again and disappears, and the mobility recurs. While there are not many such instances on record, there are enough to establish the possibility of the phenomenon.

The most frequent *cause* of this breaking down of formed callus is the occurrence of some systemic disorder. Thus, in Chaplain Walter's account of Lord Anson's voyages,[1] the case of a sailor is mentioned who was attacked with *scurvy*, and "the callus of a broken bone, which had been completely formed for a long time, was found to be hereby dissolved, and the fracture seemed as if it had never been consolidated."

Norris,[2] speaking of the influence of *erysipelas*, says that he has "seen a rapid absorption of a large callus, which had produced firm union of a fracture of the lower third of the leg, occur, without any apparent cause, to such an extent as to render the fragments very movable, and necessitate a renewal of the treatment."

Fevers have been known to have a like effect, as in a case reported by Schilling.[3] An artilleryman had a fracture of the left femur, September 1, which, by the middle of November, was so firmly united that he could bear some weight on the foot. He was then attacked with typhus abdominalis (typhoid fever), and ten days afterward callus could no longer be felt, the bones moving as freely upon one another as just after the injury. In six days more the patient died. The examination exhibited no trace of callus; the broken surfaces were bloody, like those in a recent fracture, and were surrounded by a sac-like membrane, which contained some bloody fluid. Similar cases have been recorded by Mantell[4] and others.[5] A very curious case is reported by Clarke,[6] of a fast-growing boy, who had a fracture of the arm, which united; he returned to school, overworked himself in trying to obtain a prize, and broke down in health, when the fragments were found to have become disjoined.

Occasionally the retrogression does not stop here, but the fragments themselves become absorbed, as in the very remarkable case recorded by Jackson and Dwight,[7] in which almost the entire humerus disappeared after the occurrence of a second fracture. A case in many respects analogous to this is described by Gross.[1] In neither of these instances was there any apparent cause for the destruction of the bone.

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[1] A Voyage Round the World, etc., vol. i. p. 120.

[2] Op. cit. p. 52.

[3] Med. Zeitung, Sept. 16, 1840; Am. Journal of the Med. Sciences, April, 1841.

[4] Lancet, Oct. 9, 1841.

[5] Morgagni, De Sedibus et Causis Morborum, Alexander's translation, vol. iii. p. 308; Gage, Trans. of New Hampshire Med. Society, 1875, p. 93; Hammick, op. cit., p. 176.

[6] Med. Times and Gazette, Nov. 16, 1867.

[7] Boston Med. and Surg. Journal, July, 1838, and Oct. 10, 1872.

As far as can be judged from the observations published, the removal of the constitutional disorder, when it can be effected, is followed by a renewal of the process of repair of the fracture, which ultimately becomes thoroughly united.

FIBROUS UNION OF FRACTURED BONES.—The cases of *fibrous union* differ from those already described, in that the fragments become closed in at their ends by a rounded shell of bone, sometimes very thin, but more generally thick, hard, and dense; while between them and connecting them there exist fibrous bands resembling interosseous ligaments. These bands may attach the fragments end to end, in which case there has probably been absorption of some portion of bone, perhaps separated as a splinter at the time of injury; or, when there is overlapping of the fragments, the fibrous bands may bridge over the interspace between them. It seems highly probable that in some cases these bands may be in reality remnants of interosseous membrane or of intermuscular septa.

Sometimes a condition of this kind is not easy to distinguish clinically from that of false-joint, properly so called, to be presently described. But there is generally, from the length of the bands and the comparative freedom of the fragments, an even greater degree of mobility; the limb hangs like a flail, and is useless except for such actions as involve merely a straight pull on the part of the muscles.

Most of the systematic writers are at pains to assure us that results such as these have never ensued in cases treated by them; and in the majority of the instances on record, the patients have been sailors, who met with their fractures while at sea, and who were thus unavoidably deprived of the benefits of treatment until a long while—weeks or even months—had elapsed. From this fact, as well as from the general tenor of the other evidence in regard to the matter, it seems to me as if fibrous union were due much more generally to local causes than to any constitutional disorder. This view, which was maintained by Stanley, Callender, and others, has been opposed by some respectable authorities, but I think partly because the just distinction has not been drawn between these cases and those of mere delayed union.

Fibrous union is very often the only form attainable in certain bones—the patella and the olecranon, for example; and here, if it is close enough, the functions of the limb may in time be almost completely resumed. But it may also occur in any of the long bones, especially in fractures of both bones of the forearm, and in those of the cervix femoris.

The amenability of these cases to treatment is generally in inverse ratio to the time of their existence; if seen and recognized early, they may be dealt with far more readily, and the chance of success from mild measures is much greater, than if the condition above described has become thoroughly established. In the latter state of things, there is very little hope of amendment except from operative procedures, often difficult, and by no means free from danger. Sometimes, by means of prothetic apparatus, the limb may be so far stiffened as to enable the patient to use it to a certain extent. The other plans of treatment will be presently described.

COMPLETE SEPARATION of the fragments is very rarely met with, and is probably always the result of atrophy of one or both portions. Norris[2] speaks of these cases; and I think that I have seen such a condition in the humerus, but I could not be sure that there was not a connection by very long and loose fibrous strips, between the ends of the bone. No case is known to me, in which complete separation has been placed beyond a doubt by dissection.

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[1] Op. cit., vol. i. p. 929.

[2] Op. cit., p. 21.

False Joint or Pseudarthrosis.—This term is strictly applicable only to cases in which there is formed at the seat of fracture an imitation of a normal articulation, as in the annexed diagram (Fig. 586). The periosteum, and perhaps other fibrous tissues in the neighborhood, become thickened and developed into a sort of capsule. By constant motion upon one another, the fragments become rounded, one at the centre of the end, the other at the margin, so that one is convex and the other concave; and between them, within the newly-formed capsule, there occurs a secretion not unlike the synovia of a true joint.

Fig. 586.

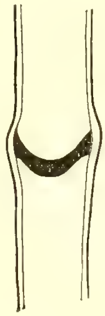

Diagram of false joint.

This state of things is more apt to occur, or, at least, has been oftener met with, in the shaft of the humerus than elsewhere; but it is not always easy to ascertain from the statements of writers what the exact condition of the bones may have been in cases treated by them. And, indeed, it may be questioned whether it would not be well to retain simply the two terms, *delayed union* and *false joint*, the latter embracing all the cases in which, whether with fibrous union loose enough to admit of a wide range of motion, or with an imitation of a joint cavity between the fragments, there is obviously a permanent condition of mobility at the seat of fracture. With this understanding, which seems to have been already assumed by many writers, the discussion would be simplified, without any real sacrifice of scientific accuracy; since, in the case of fibrous union, we have an imitation of a joint in its great essential, mobility, and, in the other case, we have but an imitation of the structures proper to a normal articulation. Clinically, the two conditions are the same (except in the treatment required, which is to be referred to again hereafter); they both differ from delayed union in the important point that the mobility in them is unattended with pain.

Otto[1] says that pseudarthrosis is not unfrequent in animals; he has seen it in dogs, cats, a fox, and several birds. He quotes Greve as having met with one example in a hare, and Tenon with one in a cat. These were probably verified by dissection.

Details of the various plans available for the treatment of the defects in the reparative process of fractures will be given in the section on the general treatment of these injuries.

Union with deformity is almost invariably the result either of want of treatment, of improper or negligent treatment, or of the restlessness of the patient. It may be simply the perpetuation of the distortion impressed upon the limb from the time of the accident, or it may be a new displacement brought about by causes acting on the limb at a later period.

Permanent deformity after fracture is by no means uncommon, and in some cases is absolutely unavoidable, by reason of the difficulty of maintaining the fragments in proper position. It may be very slight, or it may be so great as to entail upon the patient the most annoying disfigurement, and often very serious disability. Like that spoken of among the symptoms or phenomena of the original injury, it may be either angular, rotary, or lateral. One of the main objects of treatment is to prevent it; to keep the fragments of the broken bone in their normal relation, or as nearly so as may be possible, until by natural processes the repair has been fully accomplished.

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[1] Op. cit., p. 140.

Angular deformity depends for its importance largely upon the degree of the angle and the precise seat of the injury. The most frequent and striking instance of it is in the bowing outward of the femur after fracture of its shaft. Near the lower end of the humerus, an angle forward may cause great and annoying limitation of the flexion of the elbow. These and other points will, however, be discussed at greater length in connection with the special fractures concerned.

Rotary deformity is fortunately not very common. Its disastrous effect in the lower extremity, in fractures of the thigh or leg, needs no demonstration. It is not unfrequently seen in fractures of the neck of the thighbone, the foot remaining permanently everted; but here the disability from other causes is apt to be so great as to make the mere rotation outward of the foot a matter of minor moment.

When both bones of the forearm are broken, it very often happens that the upper fragments are so rotated by the action of the muscles inserted into them, that union takes place with the axes of the respective portions in a changed relation; the result is that either pronation or supination, or both, may be materially interfered with; and if to this be added any degree of angular deformity, the usefulness of the member may be lamentably impaired.

In all our consideration of the skeleton, whether in its normal condition or as modified by injury, each of its parts must be regarded, not only by itself, but as a member of a system. A deformity of the forearm affects the functions of that portion of the limb primarily, and secondarily interferes with the use of the hand. This secondary disability may be, and generally is, of vastly more consequence than the primary. It is true that in many cases there is ultimately acquired, by means of compensatory motions in other joints, a closer approximation to the original function than might at first seem possible; but this cannot be counted on, and is apt to be neither satisfactory to the patient nor creditable to the surgeon.

There remains to be considered the *lateral deformity*, the chief effect of which is to shorten the bone; and perhaps this will be the most convenient point at which to speak of certain recent observations which have altered the views of surgeons both as to the importance of this matter, and as to the possibility of correctly appreciating shortening in any given case.

Shortening may be caused, in fractures of the long bones, either by malposition of the fragments, and especially by their overlapping each other; or by loss of fragments, as in compound comminuted fractures, where it may be that portions are so wholly separated as to demand immediate removal lest they should act as foreign bodies, or where portions may become necrosed and call for extraction during the later progress of the case; or lastly, by the absorption of the bony substance of the ends of the fragments. The latter occurrence is probably rare, but there is abundant evidence of its possibility, and it may be that it is sometimes an unsuspected element in the apparently unaccountable loss of length in fractured limbs.

The question, whether or not shortening is an unavoidable consequence of fractures of the long bones, has been discussed with much zeal; some surgeons claiming that under proper treatment it ought not to occur, and others insisting that no care or skill can prevent it. It would not, however, be worth while to quote opinions on this point, since recent researches have clearly shown that absolute equality between the two limbs of a pair, or between corresponding bones, is not the uniform rule.

From observations recorded by Hunt, Cox, Wight, Roberts, Garson, and

Dwight,[1] it would seem that the difference is never very great, but varies within somewhat narrow limits. Garson measured carefully the lower limbs of 70 skeletons, of various ages from 12 years upwards. He found that only seven, or 10 per cent. of these, had right and left limbs of equal length, and in two cases only did the femur and tibia of one side correspond respectively to the femur and tibia of the other. In the remaining five cases it was by compensation that the limbs were equal; the tibia being shorter where the femur was longer, or *vice versa.* He found the tendency to variation greater in the femur than in the tibia. In 25 instances, or 35.8 per cent., the right limb was longer than the left, the average difference being 3.3 mm. In 38 instances, or 54.3 per cent., the left was longer than the right, the average difference being 4.8 mm. The left limb, therefore, was not only more frequently longer than the right, but the difference between the limbs was greater, on an average, when it was the longer than when the right was the longer, the greatest difference in the latter case being 8 mm., whereas in the former it was 13 mm. Over the whole 70 cases, the left limb was 1.5 mm. longer than the right. On farther analyzing the differences:—

> "We find that in 41 cases the left femur is longer than the right, and in these its average preponderance is 3.8 mm.; in 20 cases the right is longer than the left, the average preponderance being 2.9 mm.; and in 9 cases the bones are equal. Again, in 24 cases the left tibia is longer than the right, the average preponderance being 3.0 mm.; in 29 cases the right is longer than the left, the average preponderance being 2.6 mm.; and in 7 instances the bones are equal."

Garson hints at a very important matter, which will probably have already occurred to the reader—that there may be inequalities between the ossa innominata of the right and left side, which may be either compensatory or otherwise as regards the unequal lengths of the corresponding limbs. This point, which has not yet been at all satisfactorily investigated, would obviously affect the bearing of the results above quoted upon the surgical measurements of limbs as ordinarily made, from the anterior superior spines of the ilia to the inner malleoli.

Dwight says, in regard to the clavicle, that he found only six pairs equal out of 22 cases examined by him. The greatest difference noted was .39 of an inch. In all but two of the cases of inequality, the left clavicle was the longer.

It must not, however, be inferred that the correction of shortening likely to result from fractures of the long bones is a matter of small importance, or that the surgeon will be justified in neglecting it when called upon to treat such injuries. On the contrary, careful attention should always be paid to it; measurements should be made from time to time, especially during the earlier period of each case, and suitable means adopted for overcoming any tendency to overlapping of the fragments.

When shortening occurs from loss or absorption of portions of bone, it is of course wholly unavoidable. In the former case, the fact of the loss will be known, and in the latter it may be inferred from the absence of overriding; the fragments will be in proper relation, and even if at first there is some exuberance of callus, the bone will eventually be almost normal in shape.

Shortening is, indeed, under any circumstances, of much less moment than angular or rotary displacement, either of which must very gravely affect the usefulness of either the upper or lower extremity. The effects of such deformities, as well as the means of detecting and overcoming them, will be pointed out in connection with special fractures.

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[1] Hunt, Phila. Medical Times, Jan. 16, 1875, and Am. Journ. of the Med. Sciences, Jan. 1879; Cox, Am. Journ. of the Med. Sciences, April, 1875; Wight, Arch. of Clin. Surgery, Feb. 1877, and Proc. of the Med. Soc. of the County of Kings, 1878; Roberts, Phila. Med. Times, Aug. 3, 1878; Garson, Journal of Anat. and Physiology, July, 1879; Dwight, Identification of the Human Skeleton, Boston, 1878.

General Treatment of Fractures.

The broad principles of the treatment of fractures are very easily laid down: to restore the normal relation of the fragments as early and completely as possible, and to adopt the best means of keeping them so until their union shall have been accomplished. But in the application of these principles a vast number of details must be taken into account, and the circumstances may vary so widely as to make what would be good practice in one case wholly improper in another. Without attempting to enumerate all these details, or all the different conditions arising to modify treatment, I shall mention briefly such leading matters as concern the surgeon in dealing with this class of cases; in regard to those of minor importance, experience and common sense will be his best guides.

First Attentions to the Patient.—Occasionally, when it is one of the bones of the upper extremity that is broken, the patient comes to the surgeon's office. More frequently, the latter is sent for after the sufferer has been taken home, or to the place where he is to be treated; and sometimes, especially if the injury is severe, or if it affects a lower extremity, the surgeon's first services are rendered at the scene of the accident, or in some neighboring house.

Circumstances must determine whether the exact character of the injury shall be ascertained at once, or after the patient has been removed to his room, perhaps to his bed. If there be much suffering, or shock, it may be better to adopt temporary measures for the relief of these conditions, especially if the distance to be gone over is considerable. By a careful and gentle handling of the limb complained of, over the clothing, a general idea may be acquired of the seat and character of the injury; but if there be a compound fracture a more thorough examination should be instituted, lest bleeding or some other complication demanding relief should be present. Perhaps it is unnecessary to say that the surgeon's manner should be firm, calm, and reassuring, and his manipulations carried on with a steady and gentle hand. Shock may be combated by stimulants sparingly but frequently given; pain generally subsides upon the application of proper temporary dressings. These may be made out of simple or even rude materials; an old blanket and two or three shingles or barrel-staves, or even a mere truss of straw, may be so bound around a broken leg or thigh as to give it support and comfort until more suitable appliances can be had.

The transportation should be arranged for by the surgeon, and, in bad cases, effected under his eye. If it is to be done by hand, it is best to have the bearers of about equal height, if possible, and, in lifting the patient on to the stretcher or other means of conveyance, the surgeon should himself take charge of the broken limb. The bearers should *not* keep step, as this results in a regular swaying motion, which sometimes gives great pain at the seat of fracture; they should, however, walk as evenly and steadily together as possible.

The best form of wheeled vehicle, for fractures of the lower extremity, is a wagon, into which the stretcher can be lifted with the patient upon it. For cases affecting the arm, a carriage does as well; the injured limb should be carefully placed in a sling, and steadied with the patient's other hand.

Arrived at the place of destination, the surgeon should see the room in which the patient is to lie, and the approaches to it, and should so direct the bearers that there shall be no awkward changes or turnings to be made in reaching it. The best kind of bed is a narrow one, with a firm mattress on top; it makes very little difference whether there are feathers, straw, or springs below, provided that they give a good and equable support. The surgeon still taking charge of the injured limb, the patient should now be lifted firmly, promptly, and gently, and laid on the bed in such a position that the fracture can be gotten at with facility for the purposes of examination and dressing. It will readily be perceived that all these manœuvres will be much easier in the case of a child, a light person, or one who can help himself somewhat, than under opposite circumstances; they may present extreme difficulty if the patient is very heavy, or otherwise infirm and helpless.

Sometimes, as already said, all this has been done before the arrival of the surgeon; or the accident may have taken place in or close by the patient's house. In either case, the next step is to remove the clothing, and examine the injury. Often it is better simply to rip or tear the clothing away; but to poor people this may be a serious affair, and one to be avoided if possible. Under such circumstances everything should be loosened, and the sound arm or leg first stripped, when the rest is an easy matter. Too often the patient is needlessly exposed, and may take cold; he should be at once covered up with blankets or any other convenient wraps.

The surgeon should next carefully examine into the nature and extent of the injury, if he has not already done so. If his previous investigation has satisfied him on these points, he may keep the temporary dressings in place until he has prepared those which he intends to apply. Not unfrequently anæsthesia is required to facilitate this inquiry, as well as the correction of displacement—the setting or reduction of the fracture. Much pain may be thus saved to the patient, and the surgeon's task is rendered easier by the abolition of muscular resistance.

Reduction.—It is now an established rule in surgery, that the reduction of a fracture should be effected at the earliest available moment. Otherwise the muscles become shortened, and not only the difficulty of the procedure itself, but the risk of inflammation and of other unpleasant symptoms, from the pressure of the fragments upon vessels or nerves, may be rendered much greater.

The process of setting or reduction consists simply in the overcoming of whatever displacement of the fragments may be present, and restoring the normal shape of the bone as accurately as possible. Very generally the deformity, as mentioned in a preceding page, is somewhat complicated; so that the broken ends may have overlapped, or may be engaged together by their irregularities, and at the same time not only placed at an angle, but rotated in reference to one another. When there are two bones, as in the forearm or leg, and both are fractured, it will readily be seen that the different fragments may become so entangled, either with one another or with the interosseous membrane, as to present a condition equally difficult to recognize and to correct.

In some cases a broken bone may be set with scarcely any trouble to the surgeon, or pain to the patient; but occasionally—rarely, it is true—the displacement cannot be corrected by any available means. Between these two extremes there are innumerable gradations. The amount of difficulty encountered is by no means proportioned directly to that of displacement; on the contrary, a very slight change in the relation of the broken ends may be so maintained by the interlocking of their serrations as to baffle every effort of the surgeon to disengage them. Especially is this apt to be the case when the fracture is situated close to a joint, so that one of the fragments is too small to afford much purchase. Sometimes the difficulty may be due to the entanglement of one fragment in a tendon, looped, as it were, around it.

On the other hand, if the deformity is easily reduced, it is apt to recur with equal readiness. Very oblique fractures of the shafts of the long bones can generally be drawn into place without much trouble; but the causes of displacement have like facility of action, and a certain amount of shortening is almost sure to result. Fractures of the radius near the wrist, those of the femur near the knee, and those of the leg near the ankle (not in either case entering the joints), are very difficult to reduce, the first named especially; and they are often, no doubt, only partially brought into place; yet, when this is once accomplished, very simple retentive means will suffice to obviate the recurrence of the displacement.

Under all circumstances it should be borne in mind that the fragments can only be restored by reversing the process of their displacement; they must go back by the same way by which they came into their false position. And it is of the utmost importance that the surgeon should know that the reduction is complete; it is not enough that the outward form of the limb is restored, for this is sometimes deceptive. The soft parts may be pulled and stretched, and the swelling may mask the deformity, while the false relation of the fragments remains unchanged. Hence the most rigid examination should be made during and after the efforts at replacement, and the exact condition of things should be determined. If restoration be found to be impossible, the fact ought materially to influence the prognosis given to the patient and his friends.

An essential part of the process of reduction, in most cases, is the making extension and counter-extension. In children, or with the smaller bones of adults, the surgeon may often accomplish this with his own hands, grasping the limb above and below the seat of the injury; at the same time with his thumbs he can push the fragments into position. But in larger limbs, and in all the more difficult cases, it is better to have one or two assistants to apply this extension, while the surgeon has both hands free to mould and knead the fragments. Rotary and angular displacements are to be corrected at the same time that extension is made, the sound limb being taken as a guide for the normal shape, and certain lines and landmarks, to be hereafter mentioned, being kept in view as tests of the accuracy of the restoration.

Some differences of opinion have existed as to the best way of making extension, whether the force should be applied as far from the fracture as possible, or close to it. The true rule would seem to be that in each case the surgeon should be guided by circumstances. In very muscular and closely knit limbs, as, for instance, in a fracture of the thigh in a powerful adult, it may be found necessary, in order to make extension, for one assistant to put the bend of the left elbow under the patient's knee, and with his right hand grasp the patient's ankle, flexing the leg; while, for counter-extension, another assistant may either have a towel or sheet folded and applied to the perineum, the ends being tied around a stout stick for him to grasp, or he may, if very strong, clasp his own hands together over the perineum. In loose-jointed patients, traction at a distance from the fractured bone may simply put the ligamentous structures on the stretch; but in such persons there is apt to be less muscular resistance to reduction.

With regard to the process of measurement, and the points from and to which measurement is to be made, details will be given in connection with the fractures of special bones.

DRESSING THE FRACTURE.—Reduction having been effected, with the aid of an anæsthetic if necessary, the next thing is to secure the fracture, so that the healing process shall go on undisturbed, with the broken ends in their restored relation. Countless contrivances have been brought forward for this purpose, some costly and complicated, some cheap and simple. I have no hesitation in advising against the use of the former. The best results can be obtained with the simplest means, applied with such dexterity as every surgeon ought to have, with a clear idea of the object in view, and watched with conscientious care. Without such intelligent skill and care, the most elaborate and expensive apparatus may fail to answer the purpose.

Splints and *bandages* are very extensively used in the treatment of fractures. Various materials are used for the former: wood, binders' board, leather, felt, tin, sheet-zinc, wire-netting, and wire frames. Of these, wood has been most extensively employed, generally thin strips of white pine or deal, which should be shaped to fit the limb in every case. Scarcely any of the carved splints sold in the shops are suitable for use, as they are not made with a proper knowledge of anatomy, and must be altered by the surgeon. Dr. Jacob, of Dublin,[1] recommended strips of the bark of trees, cut when the sap was rising, for splints for fractures (in children especially); and Dr. Grant,[2] of Ottawa, Can., speaks highly of spruce shavings as a material for the same purpose. Binders' board, cut in the requisite shape, and softened in hot water, may be moulded so as to fit well, and becomes very hard on drying; and the same may be said of gutta percha, of thick leather, and of felt. Tin is much less manageable, but can be adapted to some cases, if the surgeon can succeed in giving the proper measurements to the tin-smith. Sheet-zinc has no special advantage over tin, although M. Raoul Deslongchamps has extolled its virtues in a volume of several hundred pages. Wire netting is sold in sheets, and can be cut with suitable pliers; but it is generally prepared for use by the addition of a thick wire frame around the edges. Wire splints can be better described in connection with the special fractures for which they have been most extensively employed. Splints, of whatever material, should always be of exactly the proper size and shape. If too small, the edges may cut into the skin; if too wide, and especially if loosely put on, they will not give due support to the limb, nor prevent the displacement of the fragments. When wood, binders' board, or gutta percha is used, it is a good plan to bevel the edges all around, at the expense of the inner face, lest they should come in contact with the skin and irritate it, in spite of the most careful padding.

Bandages are best made of unbleached muslin, of medium weight, not too closely woven. They may be from two to three inches wide, and about six yards in length. They are rolled up for use, as described in the article on Minor Surgery.[3]

In former times, a custom prevailed of applying what was known as an "immediate" bandage to a fractured limb, in order, as was supposed, to prevent muscular contraction. This custom has now been generally abandoned, although it is still followed by some practitioners; it never can do any good, and may do much harm.

For the purpose of protecting the skin, and better adapting the pressure of the splints to the irregularities of the surface, padding is always employed. Raw cotton is the material generally chosen; it should be clean, fresh, evenly torn, and in sufficient quantity. Carded wool answers quite as well, and even better if it cannot be frequently changed, as it does not become lumpy and sodden with perspiration, as cotton does. An excellent substitute, almost always at hand, when neither cotton nor wool can be had, is found in flannel; three or four thicknesses of old blanket make a very efficient and agreeable lining for any kind of splint. Some surgeons use the article known as "canton flannel" in the same way; the soft or flocky side should always be placed in contact with the skin.

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[1] Am. Journ. of Med. Sciences, Jan. 1847; from Dublin Med. Press.

[2] British Med. Journal, Jan. 14, 1882.

[3] See Vol. I. p. 483.

By Tufnell,[1] the use of long bags of straw, as combined splint and padding, has been recommended; the straws are carefully arranged lengthwise, and the sacks are not so tightly stuffed but that they can be shaped by pressure to fit the limb. This plan, which certainly has merit, has never come into general use.

Allied to these, but of less value because less adaptable, are various forms of cushion and of padded apparatus, which do not seem to me to need description. For merely temporary support and protection, an ordinary pillow may sometimes be applied with advantage. Sand-bags are often of great use, and will be further referred to hereafter.

Water-cushions have been proposed by Jeaffreson[2] and by Thompson[3] as substitutes for padding, but have never been generally employed, and are certainly open to very decided theoretical objections, apart from their costliness. The same may be said of the air-pads of caoutchouc, devised by Gariel.[4]

Solidifying Dressings.—The employment of bandages imbued with materials which harden on drying (such as gum shellac or other gummy or resinous substances), is of very ancient date. But it had almost entirely gone out of fashion until Larrey, about 1825, revived the idea, using the bandage of Scultetus, and cushions or compresses soaked in a mixture of spirit of camphor, acetate of lead, and the whites of eggs. The apparatus thus made was allowed to remain until consolidation had taken place.[5] Some ten years later, Seutin proposed the substitution of starch for the composition above mentioned, as well as for plaster moulds, which had been used by Dieffenbach, and probably long before his time. Seutin, however, modified the plan by suggesting the division of the splint with pliers, after the lapse of a few days, not only in order to examine the state of the limb, but to refit the apparatus and insure its effectiveness. By so doing he made this method what it has been ever since, although the materials used for stiffening have been variously modified by different surgeons. Glue, paraffine, gum arabic and whiting, flour and white of egg, plaster of Paris, silicate of potassium or sodium, in different combinations or alone, have been thus used. Of all these, the best are probably the two last named, as they are cleanly, and the solidification takes place so quickly as to make them much more secure than those which "set" only after a length of time. Tripolith, a material recently employed in Germany as a substitute for plaster of Paris, is said[6] to be lighter than that substance, to harden more quickly, to be non-absorbent when once dried, and to be a trifle cheaper. Its exact composition is unknown, and I am not aware of its ever having been brought to this country.

The silicate of potassium may be bought in saturated solution of any wholesale druggist; it is applied with a clean bristle-brush, such as house-painters use, to successive layers of bandage after they are put upon the injured limb, the skin being carefully protected by a smooth and even layer of raw cotton. I have thought it well to lay two or more strips of thick muslin along the sides of the limb, one over each layer of bandage, to act as side-splints. During the application the limb should be kept in proper position by assistants grasping it above and below. Generally in about ten minutes the silicate becomes so firm that the limb may be safely laid on a pillow.

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[1] Am. Journ. of the Med. Sciences, Jan. 1847; from Dublin Med. Press.

[2] Lancet, Nov. 9, 1867.

[3] British Med. Journal, April 10, 1880.

[4] Jamain, Petite Chirurgie, p. 210. Paris, 1860.

[5] Journal de Progrès, etc., tome iv. 1827.

[6] Med. Times and Gazette, Nov. 27, 1880.

Plaster of Paris may be employed in the same way, the dry plaster being sifted into a basin of hot (or cold) water, and applied with the hands of an assistant as the surgeon puts on the bandage. The latter should be loose-meshed (what is sold in the shops as cheese or dairy muslin answers very well). The mixture is ready for use as soon as it begins to assume the consistence of thin cream; it takes rather longer to set than the silicate does. Whichever material is used, a narrow space may be left along the back (under surface) of the limb, along which in a few days the bandage may be split up with a pair of strong scissors, for the purpose of examination; and thereafter we have a moulded splint, which may be simply reapplied and kept in place by a fresh roller of bandage-muslin.

Another way of applying plaster of Paris is by means of loose-meshed bandages, filled with dry plaster, loosely rolled, and dipped into water just before they are used. In hospitals, or where these are extensively employed, it is worth while to have an apparatus[1] for imbuing the bandages with the plaster; and they should be kept in close tin boxes, or wrapped in waxed paper. To divide a plaster bandage put on in this way, the saw or pliers must be used.[2]

Still another method is known, in its best form, as the Bavarian. It consists in cutting two pieces of stuff (shrunk flannel is the best) a little more than wide enough to encircle the limb. Two rows of stitches, about an inch apart, are now carried along on either side of the middle line, so as to fasten the pieces together. The cloth now being laid under the limb, the two upper flaps are brought together above and stitched, thus encasing the limb. Next the other flaps are evenly spread with the mixed plaster, of about the consistency of thick cream; and these being brought up into place are also sewed together, and the spare stuff is cut off. The limb is thus encased within two double layers of flannel, which, by the setting of the plaster between them, will form a very firm support on each side. A roller over all will serve to reinforce the stitching, and keep the whole in place.

A somewhat similar arrangement has been proposed[3] by Mr. Jordan under the name of "laminated plaster splints." He uses six or seven layers of muslin, with plaster of Paris spread evenly between them with a spatula; they are then dipped in water and applied. A flannel bandage, or layer of cotton wadding, is put next the skin.

Some surgeons advocate the insertion of strips of tin between the layers of the plaster bandage, in order to give it strength; and in the case of very large and heavy limbs this might be desirable, as it would largely increase the firmness of the apparatus without adding materially to its weight. Ordinarily, however, it would be needless.

Paper splints, the material being saturated with starch, and applied in layers until the requisite thickness is obtained to give firm support when dry, were first suggested by Laugier.[4] The idea has since been repeatedly brought forward anew by others.

When the *fracture is compound*, the wound must of course be left uncovered for the purpose of applying suitable dressings. This may be done either by cutting the bandage as it is put on, when the proper point is reached, and beginning afresh at the other side of the gap; or by cutting a hole in the apparatus after it is finished. The former is the preferable plan; the plaster holds the cut ends of the bandage securely. The other method may involve some pain to the patient. In order to prevent soiling of the plaster-dressing by discharges, etc., it may be well coated, when dry, with copal or other varnish.

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[1] See Vol. I. p. 498.

[2] Ibid., p. 499.

[3] British Medical Journal, July 15, 1882.

[4] L'Expérience, 1 Août, 1844.

Some surgical writers recommend the insertion of hooks or staples in the plaster apparatus for the purpose of suspension of the limb; but a better and more secure arrangement for this purpose can be made by means of supplementary wire frames, in a manner to be described hereafter.

AFTER-TREATMENT OF FRACTURES.—No apparatus which will exercise rigid pressure should ever be applied to a recently broken limb, if there is much contusion, swelling, or ecchymosis. Mischief may thus arise in a very few hours, which may even cost the patient his limb and the surgeon his reputation. Fractures should always be carefully watched for the first few days, and should never be neglected at any stage of the treatment. And here I must enter a protest against what seems to me a most dangerous maxim, though it has received the sanction of some high authorities, namely, that "comfort is the sign that a fracture has been properly dressed." It is true that, as a general rule, a fracture properly dressed ceases to be painful; but it is also true that a fracture may cease to be painful although none of the indications for its proper treatment have been fulfilled. The fragments may be in very bad position, the deformity wholly uncorrected, and yet the patient be free from suffering. I have seen a man with a fracture at the middle of the leg, in the third week, lying at his ease in bed, with the foot completely everted, so that the toes pointed almost directly outward; and could cite many other cases, although, perhaps, not so marked. Actual inspection carefully made, at sufficiently frequent intervals, can alone guard against bad results; the whole limb should be examined, and nothing be left to the chance of all being right.

Fractures of the lower extremity, as a general rule, involve a long confinement to bed—those of the thigh always, and, in hospitals, those of the legs also. In private cases, I have for some years been accustomed to use such appliances for swinging broken legs as to enable the patient to sit up almost from the very first.

One of the annoyances of such confinement consists in the difficulty experienced in having the bowels moved without disturbing the fracture; and to obviate this much ingenuity has been expended in the devising of different forms of "fracture-bed." The one in common use in our hospitals is merely a mattress perforated in the centre with a round hole, filled up with a pad, except when the bowels are to be moved, when the pad is taken away and a chamber-pot put below the opening. The lower sheet must, of course, be perforated in the same way. Others have various arrangements of sections sliding in and out; and still others are made so that the patient lies on a perforated sheet of canvas, stretched on a frame, which can be raised by a mechanical contrivance, so as to allow of the vessel being pushed in under the nates. The best-known apparatus on this principle is that of Jenks, in which strips of canvas are substituted for the perforated sheet. In hospitals, where the services of assistants can always be had, the frame can be lifted by handles, like a stretcher. Except, however, in the case of fracture of both femora, these contrivances possess hardly any advantage over the common bed-pan, if the latter be carefully and skilfully used. I will therefore merely mention the fracture-beds of Earle,[1] Daniels,[2] Burge,[3] Crosby,[4] Pancoast,[5]

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[1] Practical Observations in Surgery, p. 135. London, 1823.

[2] Hamilton, op. cit., p. 474.

[3] New York Journal of Medicine, May 1, 1857.

[4] Hamilton, op. cit., p. 475.

[5] Gross, op. cit., vol. i. p. 1029.

Gariel,[1] Rabiot,[2] and Pouillien.[3] By reference to the work of Richter,[4] it will be seen that the ingenuity of German surgeons had been early exercised in the same direction, and with very analogous results.

Two objections hold against every form of perforated mattress. One is the tendency to flattening down of the stuffing toward the central hole, so that the hips of the patient come at length to rest in a hollow; this being, of course, especially likely to happen where the same mattress is used over and over again, as in hospitals. The other is the difficulty of avoiding the soiling of the edges of the opening, which requires careful attention whenever there is an evacuation either from the bowels or from the bladder. Yet these objections are not fatal, as they can be set aside by care in making and using the mattresses, as well as in their proper renovation from time to time.

Patients who are obliged to lie in bed, are often greatly relieved by even a very slight change of posture, from the shifting of the bearing-points of the body. A very old contrivance, mentioned by Turner,[5] may be used with advantage to facilitate this; it consists in a strong cord attached to any convenient point above (a frame connected with the bed, or one of the joists of the room), and having its lower end hanging free, with a stick fastened transversely across it so as to serve as a handle by which the patient can raise, turn, and shift his body.

Many other forms of apparatus are employed in the treatment of fractures—such as fracture-boxes, inclined planes, means of making extension and counter-extension, and appliances for suspension—which may be more conveniently described in connection with the special cases for which they are designed.

The general rule may be laid down, that in fracture near a joint the dressing should be arranged so as to immobilize that joint; and that in fractures of the shaft of a bone the joints above and below the seat of injury must be secured. And for the first week at least—in many cases for a much longer period—the whole limb should be kept at entire rest. Large, long, and heavy limbs, in which there is a good deal of leverage on the fragments, require more protracted confinement than small and light ones. Sometimes, as in fractures about the wrist, and in those of the lesser bones generally, the patient can be safely allowed, after the first few days, any degree of freedom of motion which does not involve pain.

Passive motion may, in my opinion, be resorted to much earlier than is the usual practice, and with great advantage; as soon, indeed, as all inflammatory symptoms have altogether subsided. In the case of the upper extremity, no assistant is needed; the surgeon may, at each removal of the apparatus, grasp the fractured portion very firmly and gently with one hand, while with the other he very cautiously flexes and extends each joint in turn. When the fracture is in the lower limb, the surgeon may use both hands to control the broken bone, while a trustworthy assistant impresses motion on the joints. Gradually, as time goes on, this process may be more and more freely carried out. Properly managed, it is productive of no pain, and goes far toward preventing the stiffening which is sometimes a very troublesome sequence of these injuries. No force should be used at any time. There are cases in which the fact of difficulty in manœuvres of this kind is important as an indication that the fragments are not in proper position.

During the later stages of the treatment, after consolidation has begun to be perceptible, it is well to add to this passive motion sponging of the limb with soap and hot water, to which, for persons of relaxed fibre especially, some whiskey or spirit of camphor may be added. This is not only agreeable to the patient, but, I believe, is positively beneficial.

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[1] Jamain, op. cit., p. 319. [2] Ibid., p. 320. [3] Ibid., p. 322.

[4] Theoretisch-praktisches Handbuch der Lehre von der Brüchen und Verrenkungen der Knochen. (Text und Atlas). Berlin, 1828.

[5] The Art of Surgery, 2d ed., vol. ii. p. 161. London, 1725.

As the union of the bone becomes more and more firm, the muscles of the limb may be stimulated by gentle friction and pinching, in order to prepare them for the renewal of their functions.

Fractures of the lower extremity must be allowed to become perfectly consolidated before the apparatus is left off, and then the limb must be accustomed by degrees to the dependent position before any attempt is made to bear weight upon it. A patient will sometimes use crutches for a few days, and feel his way, as it were, until he finds that he can support himself upon the repaired member. In the case of the upper extremity, as the bone becomes more and more firmly united, the splint may sometimes be cut off piece by piece at either end, so as give the limb gradually increasing liberty; and in this way the use of the hand may be almost imperceptibly regained. Care and judgment are as necessary in these latter stages as in the very first attentions to the case.

In fact, each portion of the treatment of a case of fracture has its own duties for the surgeon, and its own risks for the patient. At first, the reduction and the dressings must be carefully, thoroughly, and skilfully executed; while the process of union is going on, attention must be given to keeping up the proper relations of the fragments; and towards the end, the safe and complete restoration of function must be provided for. At any of these stages, neglect may be disastrous.

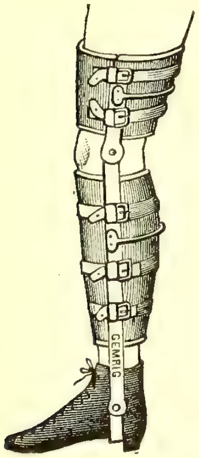
As to the treatment of the *complications* which may arise in a case of fracture, very little need be said. These intercurrent disorders should in general be dealt with as under other circumstances; they may assume such importance (*e. g.*, tetanus or pyæmia) as to overshadow entirely the local injury. The management of *compound fractures* may be best described in connection with the fractures of the several bones, as it differs in different regions of the body.

Treatment of Delayed Union and False Joint.—When the surgeon finds that the fragments are still movable upon one another at the end of the time when union might reasonably be expected, he should consider whether any constitutional defect or disorder exists, or any local condition, to which the failure can be attributed; and if such hindrance can be discovered, appropriate treatment must be instituted. Should the patient be a pregnant woman, otherwise healthy, she may be encouraged to hope that the bone will knit after her confinement shall have taken place.

As a general rule, the use of a solidifying dressing is most distinctly indicated in these cases; and my own choice is always either the plaster-of-Paris or the silicate-of-potassium bandage. It should be applied with the utmost care and accuracy, so as to keep the fragments absolutely in place, the whole limb being encased in it; and it may be left undisturbed for a much longer time than would be safe at an earlier period. On its removal, after the lapse of three or four weeks, if no change can be detected, the two portions of the limb should be firmly grasped, and the fragments rubbed together with some force, until some pain and soreness are induced. The apparatus should now be reapplied, as carefully as before, and kept on for perhaps two weeks, when the parts may be examined, and the rubbing repeated if necessary. Should there be absolutely no increase of firmness, the friction may be employed daily, with shampooing or massage of the whole limb, for three or four days; or the skin may be stimulated by a blister, or by painting it with tincture of iodine. After this the immovable apparatus may be again put on for three or four weeks.

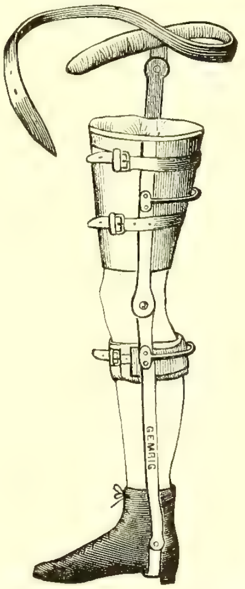
During all this time the strength of the patient should be supported and improved by nutritious diet, with tonics if need be. Certain remedies have long been supposed to have a direct effect in promoting the formation of callus. Thus the phosphate of lime and the carbonate and phosphate of magnesium, have been credited with hastening union in some cases. Probably the "osteo-colla," or "ossifrage," recommended by Hildanus, and spoken of by Turner[1] as used both internally and externally—a stone found near Darmstadt in Germany—was composed mainly of these salts. Milne-Edwards[2] found by experiments on dogs that the phosphate and carbonate of lime given internally promoted the healing of their fractures; and quotes the favorable experience of Gosselin with the same drugs, in man, given in the dose of half a gramme (about 8 grains) thrice daily. Fletcher[3] gives six cases of remarkably early union, in persons to whom lime-water and chalk-mixture had been administered. Gurlt quotes from Saucerotte a case in which a *tisane* of madder is said to have produced, in two months, union of a fracture of the leg which had been three months unhealed. Hammick[4] says, that "mercury will frequently be required by patients who never had any syphilitic taint, not only to act as an alterative, but even it will be necessary to push it to a considerable extent before union of a fractured bone will take place." He quotes a case in point, and says that "this so commonly occurs, that it will not be necessary to trouble you with the detail of any more cases in confirmation of it." As my own experience in regard to the medication of cases of delayed union has never gone beyond the use of tonics, and of anti-

Fig. 587.



Smith's apparatus for ununited fracture of the leg.

Fig. 588.



Smith's apparatus for ununited fracture of the thigh.

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[1] Op. cit., vol. ii. p. 153.

[2] Am. Journal of the Med. Sciences, Oct. 1856.

[3] Lancet, 1846.

[4] Op. cit., p. 118.

syphilitic remedies in some cases where there was suspicion of a venereal taint, I quote the foregoing statements, without comment.

In the great majority of cases of delayed union, perseverance in the line of treatment now laid down will be rewarded by success. When three months have elapsed, if there is not an encouraging increase in the firmness of the union, the patient may be allowed some use of the limb, with the safeguard either of the plaster bandage or of a prothetic apparatus, such as that devised by Dr. H. H. Smith[1] (Figs. 587, 588). This consists essentially of a jointed splint composed of steel bars, with padded straps to confine it to the limb. Success has also been reported[2] to have been obtained by the use of tourniquets applied so as to exert slight pressure over the seat of fracture. Percussion by means of the fist or a hammer, the limb being protected by a padded leather splint, was proposed several years ago by Thomas, of Liverpool, and has lately been reported on favorably.[3] Electricity[4] and galvanism[5] have been occasionally employed with apparent benefit.

Gurlt[6] speaks with commendation of the forcible tearing asunder of the uniting medium, the patient being of course placed under an anæsthetic, and the operation so performed as to involve nothing but the fibrous bands holding the fragments together.

The modes of procedure thus far mentioned have been such as involve no wounding of the skin, which for obvious reasons it is better to avoid if possible. Sometimes, however, it is expedient to use means which shall directly affect the ends of the fragments, or the intermediate tissue. Thus *stimulating injections* were used in 1833, by Hulse,[7] with success. Another case was reported by Bourguet;[8] but here a silicated apparatus was also applied, and phosphate of lime was given internally.

Subcutaneous puncture, first recommended by Miller,[9] has been successful in my hands, in a case of false joint in the thumb, in a child;[10] it is particularly adapted to this condition, but I have seen no other cases reported except two referred to by Hamilton.[11] It consists simply in passing a narrow-bladed knife between the fragments, and scoring their ends with its edge, so as to freshen them up; in my case, I used a cataract needle. *Electro-puncture* is said by Azam[12] to have yielded a good ultimate result, although at the expense of extensive and long-continued suppuration, indicating an amount of risk to which most surgeons would hesitate to subject patients, in order to obviate a mere inconvenience.

The *seton* was first employed by Physick in 1802, in a case of ununited fracture of the humerus,[13] and for many years was by far the most efficient means of obtaining union; the list of reported cases in which it has been used would be too long to cite. It was kept in place for varying periods, from a few days to many months. Somme, of Antwerp, wishing to affect a larger surface, passed a wire loop between the fragments.[1] At present the seton has been abandoned in favor of more certain methods; it was not free from danger, and I have myself witnessed a death from its use.

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[1] Am. Journal of the Med. Sciences, Jan. 1848. The idea was not new, having been successfully carried out by White in 1768.

[2] Ibid., Nov. 1834.

[3] Jones, Medical News, Nov. 18, 1882; from Lancet, Oct. 28.

[4] Lente, New York Med. Journal, Nov. 1850.

[5] Burman, Am. Journ. of the Med. Sciences, April, 1848, from Provincial Med. and Surg. Journal, December 1, 1847.

[6] Op. cit., Bd. i. S. 652.

[7] Am. Journ. of the Med. Sciences, Feb. 1834.

[8] Ibid., April, 1874, from L'Union Médicale, 10 Fev.

[9] Principles of Surgery, Am. ed. 1845, p. 503.

[10] Am. Journ. of the Med. Sciences, July, 1875.

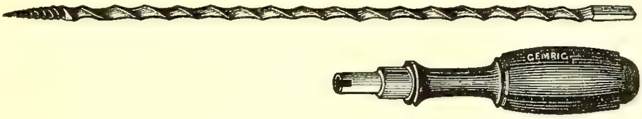
[11] Op cit., p. 81; Trans. of Am. Med. Association, 1850.

[12] Mém. et Bull. de la Soc. Méd.-Chir., etc. de Bordeaux; review in Am. Journ. of the Med. Sciences, Jan. 1868, p. 180.

[13] Medical Repository, New York, 1804; Am. Journ. of the Med. Sciences, Nov. 1830.

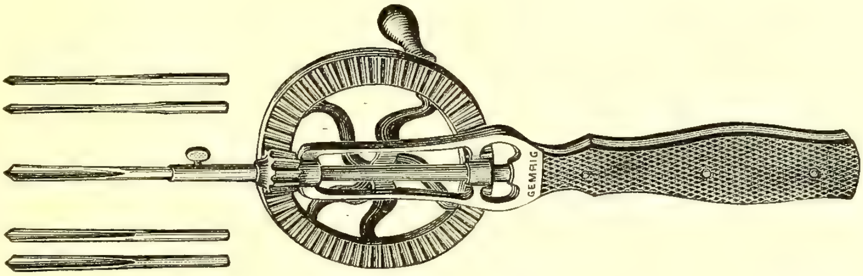
Drilling of the fragments has been practised by many surgeons, with a large measure of success; it may be done with an ordinary gimlet, although various forms of more surgical-looking instruments have been devised for the purpose. Fig. 589 represents that employed by the late Prof. J. Pancoast; and Fig. 590 a more complex, but very convenient instrument, invented by Mr. T. Gemrig. Dieffenbach's plan of introducing *ivory pegs* into the holes thus made in the bone, enjoyed for a time a high place in surgical esteem, and has not yet been wholly given up. Bickersteth[2] is said to have described, in 1854, a modification of Dieffenbach's process, which proved very efficient; it consisted in drilling the broken ends, and nailing them together with ivory pegs. Anderson[3] reports a case in which the pegs were not removed for four months, and quotes from Trendelenburg one in which they were allowed to remain for a year and a half. From an observation reported by Riedinger to the tenth German Surgical Congress,[4] it would appear that ivory pegs buried in a human bone need not undergo absorption, but may remain for years without exciting reaction; any portion, however, which may project outside of the periosteum, does become absorbed at that level, and drops off.

Fig. 589.



Pancoast's screw for ununited fracture.

Fig. 590.



Improved drill for ununited fracture.

M. Schede, of Hamburg, recently exhibited to the Congress of the German Society of Surgery,[5] some *gilt steel needles*, three and a half centimetres in length, and two millimetres in thickness, used with advantage by him in cases of pseudarthrosis. Ten or twelve of these needles are inserted into the softened part of the bone, without any complaint of pain on the part of the patient; an antiseptic dressing is then applied. The needles are kept in place about fifteen days. So far, M. Schede says, this simple and convenient procedure has succeeded in all the cases in which it has been employed.

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[1] Med.-Chirurgical Transactions, vol. xvi. 1830.

[2] Note signed "W. T. C.," Lancet, Dec. 16, 1882.

[3] Trans. of Pathological Society of London, 1881.

[4] Verhandlungen, 1881, S. 167.

[5] Gaz. Méd. de Paris, Aug. 12, 1882.

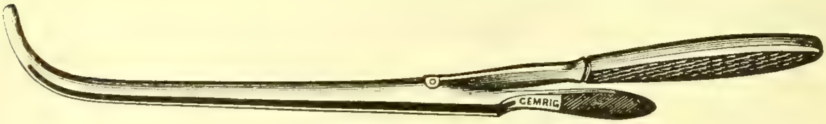
Remedial measures such as those now described are suited for cases of delayed union, and for those in which the fragments, although movable upon one another, are yet in relation by somewhat wide surfaces. But they would have failed in the instance, for example, reported by Dorland,[1] in which a portion of muscle was caught between the fragments. Stanley[2] mentions a like case. They would be equally useless where the fragments were rounded off, walled in at the ends, and connected by well-defined ligamentous bands. Here nothing short of the exposure of the bone, the renovating of the broken ends, and the securing of their apposition, could be of any avail.

Perhaps the indications for such grave interference with the parts may be stated to be, in general terms, the obstinate persistence of mobility, with pain and other evidence of some unusual obstacle to union; or the very great degree of mobility, with subsidence of all swelling, and entire absence of pain or tenderness. In one or two instances I have been able to make out the rounded and atrophied condition of the fragments.

Of the old plans of refreshing the broken ends by means of the *actual* or *potential cautery*, nothing need be said, except that while the probability of their doing good is very small, the possibility of their doing harm by setting up osteo-myelitis is too real to be overlooked. They should be accorded a merely historical importance.

Resection for ununited fracture dates back to 1760, and the credit of it is due to White,[3] of Manchester, who practised it with brilliant success in a number of instances. It involves the complete exposure of the fractured ends, which are then freshened by scraping, or by cutting them off on either side with a saw or with bone-nippers. The bone-director (Fig. 591) is very useful in turning out the ends to be sawed off. The incision should always be made where the bone is most accessible, and where there is least risk of injury to important structures. Any large vessels or nerves which are exposed, should be carefully held aside with blunt hooks, and the chain-saw will be found more convenient in every way than any other. Listerian precautions may be adopted by those who think that they diminish the danger of such procedures; if they do no good, they will do no harm. As a rule, both fragments should be attacked, although success has sometimes been achieved by section of one only, the other having been beyond reach except by greatly increasing the magnitude and difficulty of the operation, as well as the risk to the patient.

Fig. 591.



Blandin's bone-director.

The earlier operators in this direction were content to employ, after the cutting of the bones, a carefully adapted apparatus for retaining them in place. An improvement was introduced by Horeau, in 1805, in the tying together of the obliquely divided fragments by a *metallic wire* carried around them; and a still further advance was made in 1838, by Dr. Rodgers, of New

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[1] Canada Med. and Surg. Journal, 1881.
[2] Dublin Med. Press, Aug. 2, 1854; Am. Journ. of the Med. Sciences, Oct. 1854.
[3] Cases in Surgery: London, 1770, pp. 69 *et seq.*

York,[1] in passing the wire through holes drilled in the walls of the fragments, so as to keep them in apposition. Many cases of union brought about in this way are upon record; it is especially applicable where there are two bones, and those very movable, as in the forearm. Dr. H. J. Bigelow[2] attaches importance to stripping up the periosteum from the fragments, for a short distance, before dividing the bony structure. Other American surgeons who have operated in this way with success are Brainard,[3] Byrd,[4] Jones,[5] Sanborn,[6] Ashhurst, and myself.[7] Cases are also reported by Annandale,[8] and Renton.[9] A somewhat more complicated device was employed by Le Moyne,[10] in the shape of a *steel clamp*, drilling and ivory pegs having been previously used without success. Next day the clamp was found to have started from the upper fragment; the wound was therefore reopened, and silver wires placed around clamp and fragments, so as to hold the former firmly in place. Two months after the operation union seemed to be perfect, but the wire and clamp were so firmly held that it was determined to leave them, and the wires were cut off as closely as possible. At the last report, some months afterward, the wound was almost entirely closed.

Hamilton[11] speaks of having on one occasion engaged the end of one fragment in the medullary canal of the other, but does not state with what success. Roux[12] did the same, but, although no bad symptoms ensued, a fall at the end of two months caused such fresh injury that the arm was amputated. It would be interesting to know what was the state of the bone which had been so treated.

Nussbaum is reported[13] to have operated by *transplantation* in a case of fracture of the ulna with loss of substance. He cut a portion two inches long, comprising about half the thickness of the bone, from the upper fragment, and, without severing its fibrous attachments entirely, he shifted it downwards so as to fill up the gap. The result is said to have been entirely satisfactory. Such a procedure could scarcely be undertaken except by a surgeon with shoulders broad enough to take the consequences of possible failure.

Having now passed in review the various plans which have from time to time been employed for the cure of pseudarthrosis, the subject may be dismissed with a few general remarks.

In the first place, the milder measures should be first adopted, where they offer any chance of success. In cases of long standing, where the broken ends have obviously become rounded off, and are completely separated, there may be no reason for delay; and here resection and wiring seems to me to be the safest and most certain of the methods. But in more hopeful cases, after rest and accurate adaptation have been tried, with rubbing of the fragments upon one another, drilling may be resorted to, with or without the insertion of ivory pegs. Failing all these, an operation may be determined upon.

As to the gravity of resection, it has been by some surgeons over-estimated, and by others, perhaps, not sufficiently appreciated. The condition brought about is not precisely that of compound fracture, since there is far less injury inflicted on the soft parts, and the previous pathological processes have established a certain tolerance in the tissues which does not exist in a healthy limb suddenly subjected to violence. Moreover, the surgeon should be on his guard against all the avoidable sources of trouble, and may, before operating, assure himself that the patient is in such a state as to reduce the chances of failure to a minimum. On the other hand, however, there are risks which must be run; and the question is always to be carefully considered, whether the object to be gained is sufficient to justify taking them.

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[1] Heard, New York Journal of Medicine, Oct. 1839.

[2] Ununited Fractures successfully treated, with Remarks on the Operation. By Henry J. Bigelow, M.D., etc. Boston, 1867.

[3] Northwestern Med. and Surg. Journal, Aug. 1848.

[4] Richmond and Louisville Med. Journal, Oct. 1874, and N. Y. Med. Journal, May, 1876.

[5] Am. Journal of the Med. Sciences, July, 1866.

[6] Ibid., July, 1859, and April, 1860.

[7] Ibid., July, 1875.

[8] British Med. Journal, Jan. 9, 1875.

[9] Lancet, July 22, 1882.

[10] Am. Journal of the Med. Sciences, April, 1879.

[11] Op. cit., p. 82.

[12] Malgaigne, op. cit., t. i. p. 315. Translation, p. 255.

[13] Med. Times and Gazette, April 24, 1875.

For the condition of some limbs affected with pseudarthrosis is by no means intolerable. Many a man is able to earn his living in spite of such a drawback, especially if it is the upper extremity which is affected. Even without any prothetic apparatus, such a thing may be. Thus Dr. Sutton[1] reported the case of a man who was shot in the arm, the ball passing through the humerus just above the condyles. It would appear that no very strict treatment was pursued. After some weeks, he regularly bent his arm every day. This arm got well with the elbow stiff, and a false joint at the place of fracture. The artificial joint supplied the place both of the elbow-joint and of the rotary motion of the forearm, in a very perfect manner; and the man was able to do a good day's work at any kind of labor. Norris[2] quotes a number of analogous cases.

It must further be remarked that the surgeon must be cautious in his promises to the patient as to the amount of benefit to be derived from operation. Although, as a general rule, the union of the broken bone may be expected, there may be a failure; and even if the main object be accomplished, there may be drawbacks to the ultimate result, which will cause much disappointment to the patient if his hopes have been raised too high. In illustration of this I may mention a case which came under my notice some years ago:—

R. G., aged 36, sustained a fracture of the right femur in December, 1865, in Nevada, and was kept in bed six weeks, with a screw extension apparatus. No union taking place, a seton was passed June 10, 1866; this failing, a steel screw was introduced November 3, and kept in for seven weeks. Abscesses formed on either side of the patella during that time, but the bone became firm. When I saw him several years afterwards, he had three inches shortening, the lower fragment being behind the upper. Only slight flexion of the knee was possible. He could walk very well, and all day, but not fast.

Had this patient been assured, after the manner of some over-sanguine surgeons, that he would be able to walk as well as ever, he would have had just cause of complaint, although the ultimate result was perhaps the best that could have been obtained.

Amputation has been resorted to in some cases of pseudarthrosis. It is of course only justifiable when the limb, after a thorough trial of all reasonable means, not only fails to unite, but remains in such a condition as to be a burden to the patient. Thus when the bone affected is in the lower extremity, and the fragments very loosely connected, the usefulness of the limb as a means of support and progression is lost, and the patient may be disabled from obtaining a livelihood. Or if there be extensive necrosis, or absorption of a very large portion of the bone, so that the member hangs dangling like a flail, it may be a mere incumbrance.

Persons in good pecuniary circumstances may often be enabled by means of prothetic apparatus to obtain a fair degree of use of a limb which would otherwise be only in the way; and even among the poor this should be suggested as a possibility. For example, if the humerus be the bone concerned, an appliance for its external support may, even if rude and homely, give the patient such use of the forearm and hand as would be far better than any artificial substitute.

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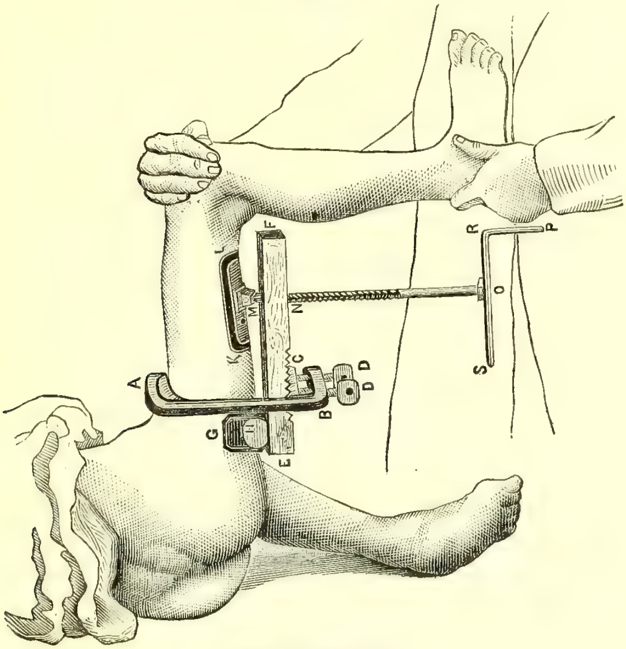
[1] Western Journal of Med. and Surgery, Oct. 1842.

[2] Op. cit., p. 56.

In any case it is a good rule for the surgeon to wait until the patient asks for the removal of the limb; and to satisfy himself, before consenting to a resort to this extreme measure, that there is no available method of restoring some degree at least of the usefulness of the part.

Treatment of Union with Deformity.—If from restlessness or insubordination on the part of the patient, a fracture is found to be uniting in bad position, no time should be lost in correcting the deformity, and in so modifying the dressings as to make a more efficient retention of the fragments. The means of doing this must vary with the part concerned, and with the circumstances under which the treatment is conducted. Occasionally, the end may be gained by gradual pressure with properly padded splints; but, generally speaking, it is the better plan to bring the bone into good shape at once, the patient being etherized if necessary; and this may often be done with the surgeon's hands applied at either end of the bone, while his knee is used as a fulcrum. Should the union be already too firm for such force to be effective, the bone may be straightened over the padded edge of a table, with the aid of assistants. Or an "*osteoclast*," such as that represented in Fig. 592, devised by Dr. C. F. Taylor, of New York, may be employed. In whatever way the thing be done, care should be taken to exert the force exactly on the spot desired, and to get as much leverage on the bone as possible; otherwise greater pressure will be necessary, or a second fracture may be produced at some other portion of the bone. The soft parts should always be well protected, and pressure upon large vessels or nerves should be studiously avoided.

Fig. 592.



Taylor's osteoclast.

For retaining the fragments in their improved position, a very rigid splint, properly shaped and padded, may be put along either side of the limb, and accurately bandaged. Firm compresses may be put under the padding, between it and the splint, at any points where special pressure is desired; and if extension seem to be needed, it may be made by an adaptation of methods to be hereafter described.

When consolidation has actually taken place, and the bone is permanently fixed in its distorted condition, there are several courses open to the surgeon. Brainard[1] advised weakening the bony texture at the seat of fracture, by *drilling* it subcutaneously, and then breaking it up in the manner already described. It must, however, be borne in mind that re-fracture is by no means a trifling affair. Union may fail to occur after it, whether it be accidental or produced intentionally by the surgeon; and symptoms of great gravity may ensue, as in a case reported by Hunt,[2] in which the patient, though he ultimately recovered with a useful limb, was placed in imminent danger of his life by the operation.

Resection of a wedge-shaped piece of bone from the projecting angle has been done in a large number of cases.[3] It dates back as far as the sixteenth century, and from the published reports would seem to have been very generally successful. Yet there are not wanting accounts of its failure, and I have myself seen several instances in which it has proved fatal.

Subcutaneous osteotomy, either with the saw after the method of Adams, or with the chisel of Linhart and Maunder, is certainly a safer procedure; but for obvious reasons it would sometimes afford much less advantage in the correction of the deformity.

The deformities which are most frequently met with after fracture, are such as admit of no treatment. They are apt to be very close indeed to joints; I have seen them in the neighborhood of the elbow and ankle more often than elsewhere. They are mainly due to the extreme smallness of one fragment, which gives no purchase for any form of retentive apparatus; moreover, in these cases there is commonly very great swelling in the early, and even in the later stages, so that the precise condition of affairs cannot be determined until all chance of correcting it is past. Hence the surgeon, when called upon to attend fractures in these regions, should be careful to guard the patient or his friends from disappointment, and himself from blame, by stating from the outset the probability of more or less deformity and loss of movement resulting.

The foregoing remarks apply especially to the treatment of cases of angular deformity, which, indeed, is the one most generally brought to the notice of the surgeon, and the one which affords most chance of relief by operative measures. Mere shortening, after union has taken place, can scarcely be remedied, as it is due either to the loss of bone-substance or to overlapping of the fragments; and the section of a bone so united, in order to splice it anew, would be a procedure so grave in its risks as to prevent any prudent surgeon from attempting it. As to rotary displacement, disabling and disfiguring as it is, in the very rare cases in which it occurs, the prospect of improvement from an operation must be acknowledged to be too small to warrant its employment.

The subject is in practice still further narrowed by the fact that the cases which have been hitherto reported as dealt with by operation have nearly all, if not all, concerned either the leg or the thigh. Here angular deformity involves shortening of the whole limb, as well as a most awkward and inconvenient hampering of its movements, not remediable, as mere shortening is, by the wearing of a boot with a thick cork sole, or with a metallic stirrup to make up the want of length; and for such a condition the surgeon is justified in adopting severer measures, and running greater risks, than for one less distressing.

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[1] Chicago Med. Journal, Jan. 1859.

[2] Philadelphia Medical Times, Oct. 26, 1872; Surgery in the Pennsylvania Hospital, p. 151.

[3] Norris, op. cit., pp. 124 *et seq.*

One or two instances are upon record in which surgeons have shortened a sound limb in order to obviate the limp due to a badly healed fracture in the other. I mention the fact only to enter a protest against any such procedure, which, in my opinion, could never be otherwise than rash and unsurgical, and the result of which could not be satisfactory.

Reference will be again made to the subject of union with deformity in connection with certain special fractures.

FRACTURES OF SPECIAL BONES.

Fractures of the Bones of the Face.

From the size, shape, and arrangement of the bones constituting the skeleton of the face, they are, with the exception of the lower jaw, unapt to be broken singly. By crushing forces, such as a fall from a height on the face, the kick of a horse, or the passage of a wheel, very extensive injury may be inflicted. These fractures are generally compound, and often comminuted.

Cotting has reported[1] the case of a man run over by a cart, who had "a fracture of the lower jaw on one side, and a dislocation on the other; and a separation of the whole face from the base of the skull. The patient recovered without much deformity."

A man was brought to the Pennsylvania Hospital in 1855, who had had his head caught between the platform of a steam hoisting-machine and a floor. The face was separated—bones, soft parts and all—from the cranium, as far back as the sphenoid; a ghastly gash across the face, with a curious falling away of all the features from the forehead, had been produced, and the shock was so great that death ensued in a few hours.

A very remarkable case of smashing of the facial bones, not fatal, may be found recorded by Heath.[2]

Such very severe injuries are rarely met with; and the cases vary so much that they can only be discussed in the most general terms. Although at first sight they may be frightful, and it may seem as if recovery, if possible at all, would be necessarily attended with hideous deformity, the surgeon should not despair. He should endeavor to ascertain the exact extent and character of the fractures, and to replace the broken portions of all the bones involved. It may tax his ingenuity to keep them in place, but by careful adaptation of the means to be presently described, a great deal may be done. Union takes place very rapidly, and the disfigurement ultimately resulting is often far less than might at first be expected.

One rule is recognized by all the authorities in regard to compound comminuted fractures of the facial bones; it is, that splinters of bone should not be removed until they are actually necrosed and thrown off. Loss of substance produces the worst deformity; and it often happens that small fragments which seem hopelessly detached will adhere and live, perhaps helping materially to preserve the contour of the face.

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[1] American Journal of the Medical Sciences, Jan. 1850.

[2] Diseases and Injuries of the Jaws, p. 55. London, 1868.

Generally the attention of the surgeon is confined to the prevention of deformity after these injuries; but sometimes other bad consequences may ensue. Thus, Martin reports[1] a case in which amaurosis followed a fracture of the nasal portion of the superior maxilla, as well as of the palate bone, and most probably of the lachrymal; the patient, a man aged sixty, had been struck with a stone. Sight was ultimately restored.

A number of instances are on record in which foreign bodies have been forcibly thrust into the orbit, producing fracture of its bony walls, and injuring the eye, or even the brain itself; but these will be more appropriately discussed elsewhere.

The *treatment* of fractures of the facial bones must be directed to the replacement, as already said, of the fragments. This may often be done (after the careful removal of all foreign bodies, if the fracture be compound) by simply moulding with the fingers. Compresses should then be applied, exactly adapted to the size of the part over which pressure is to be made, and fastened in place by means of strips of fine isinglass plaster, or of rubber adhesive plaster. Of course the eyebrows, moustache, or any hair that may interfere with the dressing, should be carefully shaved. A light ice-bag, not filled so full as to prevent its taking the shape of the part, should be laid on, to keep down inflammation; the patient should be placed in bed; and liquid diet only should be allowed. If the effort of swallowing even this be productive of pain, or disturb the fracture, nutritive enemata may be employed.

It is rarely necessary to confine the lower jaw; but this may readily be done in case of need by means of a broad strip of rubber plaster applied under the shaven chin, and brought up with the ends crossed above the forehead.

When the fracture involves the alveolar margin of the upper maxilla, it may become necessary to have a cast taken of the teeth, and on this a vulcanized rubber mould, to serve as a splint. (In large cities it is generally easier to have this done by a dentist, to whom the process is thoroughly familiar.) Having put the splint in place, the surgeon brings up the lower jaw against it, and applies the broad strip of plaster above mentioned. A roller may be employed, in the form known as "Barton's bandage,"[2] if there be any objection to shaving the chin, or, in the case of females, to shaving the "front hair."

FRACTURES OF THE ZYGOMA.—Fractures of the *zygomatic arch* are very rare, and can only be caused by great violence. Malgaigne quotes from Duverney an account of "a young child, who, having in his mouth the end of a lace-bobbin, fell headforemost, so that the end of the bobbin, piercing the soft parts, broke the zygomatic apophysis from within outwards;" and another, in which Duverney says that he detected the fracture by passing his finger through the patient's mouth. But since, as Malgaigne justly remarks, the zygomatic arch cannot be reached in this way, there is good reason to doubt both these stories.

I have seen one case of fracture of the zygomatic arch, firmly united with deformity outward. It had occurred several months previously, by the falling of some chains on the head and left shoulder of the man, who was a sailor.

When the deformity is outward, which may perhaps result from the jamming backward of the malar bone, simple pressure inward may, in a recent case, overcome it. When it is inward, resort may be had to incision, and the introduction of an instrument to pry the fragments up. Malgaigne quotes a case thus operated upon by Ferrier, with a good result.

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[1] Medical Press and Circular, Sept. 23, 1874.

[2] See Vol. I. p. 493.

Muhlenberg[1] has recorded a case of fracture of the zygomatic process by the kick of a horse, followed by very troublesome false anchylosis of the temporo-maxillary joint.

MALAR BONE.—Fractures of the *malar* bone are exceedingly rare, as might be expected from its great strength, and from its attachments. A few instances are on record in which it has been separated from the adjoining bones, by very great force. In one, recorded by Malgaigne, there was depression, especially marked posteriorly, where the malar bone had been driven inward away from the zygomatic process of the temporal, and injury was done to the infra-orbital nerve, paralyzing the area supplied by it.

Replacement may be difficult, or even impossible; but the resulting deformity is not very great, unless from some such lesion of nerves as that just mentioned. There would be no valid objection to making a slight incision so as to introduce an elevator for the purpose of prying the bone up, as in Ferrier's case of depression of the zygomatic arch. In any such case, by making the section of the skin obliquely, the resulting scar would be materially lessened.

UPPER JAW.—Fracture of one *upper maxillary* bone is very rare, except in the alveolar portion. This is sometimes broken off by blows or falls; thus I have seen a semicircular piece detached in front, carrying with it the incisor teeth, in a man, who, having fallen from a wagon on his face, had a heavy box come down on his head as he lay; his lower jaw was also broken in two places. I have seen a much smaller piece knocked loose in a boy of six, by a fall against a step; he bled profusely for a time, but a good result ensued.

Occasionally the wall of the antrum is pierced by a thrust with a stick or sharp instrument; and in such a case the bone may be more or less splintered in various directions.

In most cases, the force fracturing the upper jaw-bone is exerted at the same time upon adjacent bones, and a more complex injury is produced. Thus the kick of a horse may crush and drive back both upper maxillæ, with the palate bones and vomer; or the same effect may be produced by a fall on the face from a height.

Wiseman[2] relates a curious instance, in which, a boy, aged 8, having had a kick from a horse, which drove the bones backward, he "caused an instrument to be made, whereby the great fractured body was more easily brought into its natural place, and also kept there by the hand of the child, his mother and my servants helping him some while." The result is said to have been "better than could have been hoped for from such a distortion in that place."

Hayes[3] reports the case of a man, who, being thrown from a carriage and striking upon the end of a fence-rail, sustained compound comminuted fractures of the right upper maxilla and right malar bone, with simple fractures of the left upper maxilla and the lower maxilla on the right side. There was a good deal of cerebral commotion, and very severe hemorrhage; but the patient ultimately did well.

A man, aged 40, was brought to the Episcopal Hospital, in December, 1876, having been injured by the caving in of a culvert. He had a compound fracture of both nasal bones, the greater part of the left one being crushed off; and a laceration of the right lower eyelid, the ball being partially torn away and falling forward in the orbit. The whole face was enormously swollen, and there was continuous and free bleeding from the nose. On the next day, the swelling having subsided, a fracture was discovered beginning near the zygomatic arch on the right side, and extending across the upper jaw to the left side in front of the molar teeth. The fractured portion was very freely movable. Plugging of the posterior nares was resorted to, but the patient persisted in pulling the tampons away, and the hemorrhage was finally arrested by means of astringent injections. About the fourteenth day an abscess formed below the right eye, although the swelling and ecchymosis had almost wholly disappeared; this continued to discharge for some weeks, but no dead bone could at any time be felt. Union of the fracture took place readily, and on January 1, when I gave up the wards to Dr. John Ashhurst, Jr., there only remained a condition of ptosis due to tearing of the muscles above the right eyeball. This was remedied by Dr. Ashhurst by operation, January 11, and on the 20th the man went out cured.

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[1] Phila. Med. Times, May 15, 1871.

[2] Op. cit., vol. ii. p. 253.

[3] South. Med. Record, 1882, p. 281.

Occasionally these injuries are productive of most ghastly deformity. Thus Malgaigne mentions a case seen by him a long time after the injury, which the patient had sustained, when a child, by the kick of a horse, comminuting the nasal, upper maxillary, and palate bones, and tearing and bruising the soft parts.

The nasal bones were destroyed; the anterior portion of the alveolar arch, and most, if not all, of the vault of the palate, had likewise disappeared. He had no nose nor mouth; the two lips being fastened together by a thick and firm cicatrix, the chin was continued up to an oval opening, formed between the two ascending processes of the maxillary bones as high as the frontal. By this one opening the patient breathed, spoke, ate and drank; when a piece of bread was put into it, the tongue was seen to come up, and to carry it down to the molar teeth, which performed their functions very well.

Concerning the symptoms and diagnosis of these cases, there is very little to be said; the nature of the injury is generally clear enough.

As to the *treatment*, the indications are to restore the fragments to their place as nearly as this can be done, and to keep them so until union, which generally takes place very readily, has occurred. In compound fractures, no splinters should be removed by the surgeon; they may unite, and if they do not, they will be thrown off. By the older surgeons, very complex appliances were devised, with head-bands, curved steel bars, and plates to press against the fragments. But the improved resources of modern dentistry render such apparatus, for the most part, needless; and in the great majority of cases the retention of the fragments can be effected by means of well-fitted vulcanite splints made to fit the dental arches. When these are arranged, a bandage is put on so as to restrain the movements of the jaws.

In some cases, after the first day or two, there is no difficulty in the administration of liquid food by the mouth, the patient learning to take it without deranging the fragments or the apparatus. But should there be any awkwardness in this, rectal alimentation may be resorted to.

FRACTURES OF THE NASAL BONES.—The bones of the nose are so thick, at their upper part, and so well supported, that they are not often broken except in their lower portions. Sometimes the septum suffers also; perhaps this is more generally the case than is suspected. It is not always easy to tell how far the injury consists also in separation of the cartilages from the edges of the bones; but this certainly does occur in some instances. The mucous membrane is often ruptured, and thus the fracture is rendered compound.

I have seen the nose broken by a cricket-ball, by a blow with the fist, by a blow received in boxing with the gloves, by a fall from a horse; the violence is always great and direct. Oftentimes it falls a little to one side or the other, so as to drive the nose crooked; and if this deformity is not corrected, it is very disfiguring.

Concussion of the brain is sometimes produced by the severity of the blow, but it seems very unlikely that the force can be transmitted through the nasal bones; it is more probable that it bears also upon the neighboring portions of the walls of the cranium.

Hamilton gives several cases of injury of the nose in children, in which the nasal processes of the upper maxillary bones were spread outwards; one of these was in a child only three weeks old, upon whose face a block of wood fell as she lay asleep. Such an occurrence could hardly take place in an adult.

The history of the injury, and the deformity, generally point to the diagnosis, which is nearly always rendered certain by the detection of crepitus. Other symptoms apt to be present are: severe pain and headache, hemorrhage from one or both nostrils, and sometimes emphysema in the surrounding areolar tissue. Swelling takes place so rapidly as often not only to make the exact seat and direction of the fracture obscure, but to interfere seriously with attempts to correct the displacement.

In many of these cases, especially if the violence inflicted has been very great, the bones are comminuted; and this adds notably to the difficulty of exact diagnosis as well as of treatment. The mere detection is easier, as well as the reduction, but the latter is hard to maintain.

Treatment.—Fractures of the nasal bones usually unite very readily, and this fact makes it very desirable that the displacement should be carefully corrected at the earliest possible moment. Hence the surgeon should at once press the fragments into their proper relation by means of an inflexible probe or director passed into the nostril, first on the one side and then on the other, moulding them at the same time with the fingers of his other hand applied on the outside. Another good plan is to use a pair of forceps. In many cases this will be sufficient; the deformity, once reduced, does not recur, and all that is needful is to keep down inflammation. Hemorrhage may be arrested by gently introducing a slender bit of ice, or by making the patient snuff up into the nose, water as hot as he can bear. Emphysema will subside of itself.

Should the fragments be so loose as to fall out of place, the attempt may be made to support them from within by means of pieces of thick soft-rubber catheters, with adhesive plaster externally; or the plan suggested by Dr. L. D. Mason[1] may be adopted. This consists in pushing through the base of the nose a strong pin (gilt or nickel-plated), and bringing a strip of rubber or adhesive plaster across from one end to the other so as to support and compress the parts.

For the treatment of *deflections of the septum* it is impossible to give any rules which shall apply to the more difficult cases, since they may require judicious modifications of operative procedures. Usually, in the simpler cases, properly applied pressure will suffice to overcome them.

Sometimes, when the nasal process of the upper maxillary bone is involved, there may be violence inflicted on the lachrymal duct. From this may arise stoppage of the duct and *fistula lachrymalis;* it is obvious that such a case would present unusual difficulties.

Malgaigne quotes from Duverney a case in which the ultimate result of an injury of this kind was a cancer, which destroyed the patient's life.

FRACTURES OF THE LOWER JAW.—The lower jaw presents the figure of a more or less pointed arch, bent upward near each buttress. Its body, comprising all in front of the angles, is thick and strong, and especially dense at the symphysis. The rami are flat and comparatively thin, widening out transversely above and posteriorly to form the condyles, while above and anteriorly they run up into the thin points known as the coronoid processes. Without a careful study of the anatomy thus briefly sketched, a proper comprehension of the fractures of this bone is impossible; and such study must embrace the relations of the condyles to the base of the skull, as well as of the arrangements of the osseous structure as seen in sections. As to the latter, it affords a very striking illustration of the law before stated, that the lamellæ always run perpendicularly to the planes of pressure, and as nearly as possible parallel with the lines of muscular action. If a line be drawn from the symphysis to the centre of either condyle, it will be found to represent the resultant of all the normal forces to which the corresponding half of the bone is subjected.

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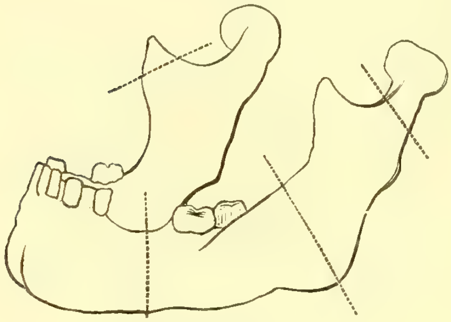
[1] Annals of Anatomy and Surgery. Brooklyn, 1880.

As might be inferred from its complicated shape, the fractures of this bone present great varieties. They may result from direct violence at almost any point, or from indirect violence at one or even at a number of points. A force from without may tend to crush down the whole arch, in which case it may give way at its apex, at two or more weak points, or, if the force be exerted somewhat obliquely, at some point on the opposite side of the arch. Occasionally there is a distinct leverage, and sometimes a pressure on one side of the arch, with a counterpressure on the other.

Fig. 593.



Fractures of the lower jaw.

The annexed diagram (Fig. 593) will serve to show the portions of the bone at which fractures are most apt to occur. The body is the part oftenest involved; it may be broken just at the symphysis (although on the authority of Boyer this was long thought to be impossible), or at a variable distance from it. Double fractures, the body being broken through at two points, are by no means rare. The angle may give way, probably always to leverage across it. Occasionally the neck of the condyle has been broken, and very rarely the coronoid process.

Fractures of the lower jaw are rarely met with in children, by reason of the small size of the bone at their age;[1] and they are infrequent also in women and old people, whose habits of life exempt them in great measure from the kind and degree of violence by which these injuries are produced. Blows of all kinds—with the fist, with weapons, by the kicks of horses, by flying masses in mining accidents—falls on the face, and crushing forces, such as the passage of a wagon-wheel, are the chief causes of fractures of the lower jaw. Hamilton states that he has seen the bone broken on both sides by the violent grasp of a hand. Gross[2] mentions the case of a man of 70, who sustained a fracture of the neck of the bone during a violent paroxysm of coughing; this case I believe to be unique.

The amount of injury done to the bone varies greatly. No other single bone is so apt to be broken in several places; a fact which is readily explained by its complex shape, and its double articulation, giving two points of resistance. Malgaigne quotes from Houzelot a case in which, the patient having been killed by a fall from a height, it was found that he had sustained fractures of the symphysis, of the neck of each condyle, and of both coronoid processes. Sir W. Fergusson[1] mentions an almost similar case, in which, however, only one coronoid process was broken. Heath[2] describes a specimen in the Museum of King's College, in which the body of the bone is fractured on either side, with the necks of both condyles. The probability is that in all these cases the force was received on the symphysis, and that the fractures were produced simultaneously, the bone yielding at all its weakest points.

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[1] Bouchut (op. cit. p. 759), says that fractures of the lower jaw are sometimes caused by the accoucheur in aiding delivery; but he cites no cases in proof of the statement. Two are quoted, however, by Gurlt (op. cit. Bd. ii. S. 409).

[2] Op. cit., vol. i. p. 940.

Another specimen mentioned by Heath will serve to illustrate multiple fracture, due, it may be supposed, to lateral compression:—

> "One fracture runs obliquely forward in front of the first molar tooth into the mental foramen. A second fracture runs vertically between the right incisor teeth. A third fracture runs very obliquely from the last molar on the right side down to the lower border of the bone opposite the canine tooth. This is met by a fourth fracture running obliquely backward in front of the first molar tooth of the same side. The lower border of the bone in the mental region is broken off and comminuted into numerous fragments, one of which contains the mental foramen of the right side. The left condyle is also broken off obliquely."

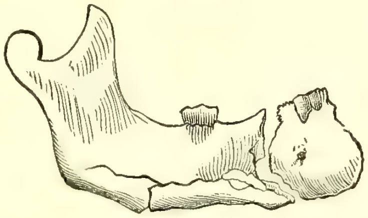
Still another is described by Heath as follows:—

> "A fracture extends obliquely backward between the second and third molar teeth of the *left* side, the external and internal plates of the bone being equally involved. There is also an oblique (downward and backward) fracture of the neck of the *right* condyle."

Fractures of the *body of the jaw-bone* are almost always compound, by laceration or rupture of the mucous membrane and underlying tissues, so that the air within the mouth gets access to the broken ends. Hence there is very apt to be suppuration, and the breath and secretions of the mouth are generally offensive from the decomposition which ensues.

The annexed sketch (Fig. 594) from a specimen in the Mütter Museum of the Philadelphia College of Physicians, shows a comminuted fracture, one portion of which, extending backward, is a mere fissure. Malgaigne quotes from Gariel an instance in which he "proved by an autopsy the existence of a fissure on a level with the dental canal, involving but part of the thickness of the bone;" the patient had fallen from a height.

Fig. 594.



Comminuted and fissured fracture of lower jaw.

When there is double fracture of the body of the jaw, the two lines of separation may be on the same side, or on opposite sides, of the symphysis. In the former case the intermediate fragment will not be as greatly displaced, or as hard to control, as in the latter.

Peirson[3] has recorded an instance of double fracture of the jaw by the passage of a wagon-wheel, in which the middle fragment of bone, with the tongue, "was forced down the throat, so as nearly to occasion suffocation. The accident occurred in the night, but fortunately near a house whose inhabitants were awake; and the patient obtained the loan of an iron spoon, with which he contrived to drag the tongue forward, and prevent the impending suffocation, till I was enabled to secure the fragments by wiring the teeth. Great swelling followed, preventing deglutition for many days; but the patient, being supported through an œsophagus tube, eventually recovered."

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[1] System of Practical Surgery, p. 457. London, 1870.

[2] Op. cit., p. 5.

[3] Remarks on Fractures. Boston, 1840.

Here it was the unopposed action of the muscles of the floor of the mouth that dragged back the fragment. Indeed, the effect of muscular action in causing or keeping up displacement is generally as clearly demonstrable in fractures of the lower jaw as in those of any other bone. In one case, in 1877, I was obliged to divide the muscles behind the symphysis, in a fracture close to that point, in order to reduce the fragment drawn back by them.

Occasionally, however, the degree of displacement is curiously slight, perhaps because the actions of different muscles counterbalance one another, as is noticed in some other parts of the skeleton also.

The signs of fracture of the body of the lower jaw are seldom very obscure, and sometimes very plain. Usually there is rapid swelling, which, when the bone is broken at one side, produces a curious twist of the face. Of course the motion of the part is limited, not only by the mere loss of continuity in the bone, but by the pain caused by it; and there is apt besides to be at least a temporary paralysis of the lip, from the injury to the inferior dental nerve. Hence speech is impaired and chewing often impossible. Profuse salivation is an almost constant symptom, and is made more apparent by the loss of control of the mouth. Sometimes, especially if the fracture be compound, the saliva is offensive, even to the patient himself. When the finger is inserted into the mouth, and the other hand applied outside, the line of the teeth is found to be abruptly irregular, and the fragments may be moved upon one another, with the production of pain, and of more or less distinct crepitus. It must be borne in mind that very few adults have perfectly regular teeth; and that even very marked irregularities do not indicate fracture, unless there is pain on pressure, and a corresponding deviation at some point on the opposite margin of the bone. Abnormal mobility, also, is very rarely wanting, though it may be so slight as to require extreme care for its detection.

The irregularity in the line of the teeth may be either transverse, one fragment being drawn down below the level of the other, or lateral, the anterior fragment generally slipping up within the posterior. This latter displacement is due partly to muscular action, but partly also to the fact noted by Malgaigne, that the plane of the fracture is apt to run inward and backward, the posterior fragment being beveled at the expense of its inner face; and this again, it seems to me, may be accounted for by the pointed arch-shape of the whole bone.

Although it would seem as if the dental nerve could never escape being torn or stretched in fractures of the body of the lower jaw, the occurrence of permanent trouble from this cause is very rare. Hamilton[1] gives one case, and refers to another seen by Désirabode.

Fractures at the *angle of the jaw* are generally oblique, in the direction shown in the annexed cut (Fig. 595), representing a specimen without history in the Mütter Museum. In this case there had been a false joint formed. Another case occurred in my ward at the Episcopal Hospital, in 1882, in the person of an elderly man who had fallen down, striking on a stone.

A much rarer form of fracture, partly involving the angle, is shown in Fig. 596; it represents a specimen also in the Mütter Museum, and of unknown history. Besides a very old and firmly united fracture, almost exactly at the symphysis, there is a recent oblique one beginning at the angle and running downward and forward to near the middle of the lower margin of the right half of the body of the bone.

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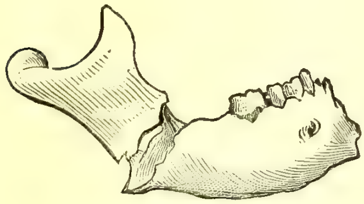
[1] Op cit., p. 127.

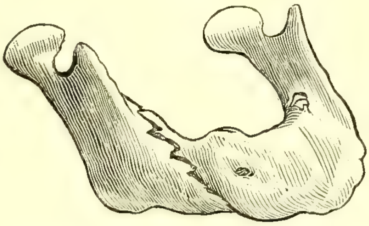
The *coronoid process* has very rarely been seen fractured; never without other lesions. Besides the cases before quoted from Houzelot and Fergusson, Gurlt gives one other, from Middeldorpf, and Tatum has reported[1] a fourth.

Fig. 595.



Fracture of lower jaw at angle.

Fig. 596.



Fracture of lower jaw at symphysis and angle.

A number of instances are on record in which the *condyloid process* has been broken, either by itself or, as in cases already referred to, along with other portions of the bone. I have seen the former condition caused by a stone, in a man injured by the premature explosion of a blast. Will[2] has reported one observed by him in a patient hurt by a falling wall. Watson[3] has recorded a case of fracture of the necks of both condyles, by a fall from a yard-arm, the jaw-bone being otherwise uninjured. Cockburn[4] gives a curious case in which by a blow on the *left* side of the face, the neck of the *right* condyle was broken. Other instances are quoted by Malgaigne, who points out that "the condyle itself remains in relation with the glenoid cavity; but the pterygoid muscle makes it execute a movement of rotation, carrying the fractured neck upward, forward, and inward, so that the fractured surface of the inferior fragment is in relation only with the posterior surface of the neck and of the condyle."

A case is reported[5] in which, along with fracture about an inch to the right of the symphysis, there was discovered after death, fifty-four days from the time of the accident (a fall from a horse), a fracture "situated in the left condyle, and extending obliquely downward and inward." If this fracture involved the condyle itself, it was, as far as my knowledge goes, altogether unique.

The symptoms of fracture of the neck of the condyle may be readily inferred; they will be more clearly made out if the fracture is on one side only. Besides crepitus, pain, and inability to move the jaw, there will be a twisting of the chin toward the injured side, which, according to Malgaigne, is apt to be permanent in cases which do not prove fatal. This twist has an obvious diagnostic significance, as in unilateral luxation the chin is directed *away* from the injured side.

Fractures of the jaw vary greatly in their degree of gravity. Even when they are compound, healing often takes place with readiness, and in cases which look very unpromising a good result may be obtained by careful and well-directed treatment. Yet it must be remembered that injuries about the face are particularly liable to be followed by *erysipelas*; and the interference with nutrition which necessarily attends the lesion in question, may be a source of serious debility, especially in persons previously broken down by hard labor and bad habits. *Hemorrhage* very rarely ensues to a troublesome degree, unless in very bad compound fractures, in which the facial artery is wounded. Stephen Smith[1] reports a case in which, on the twentieth day after fracture of the body and ramus, the patient lost a pint of blood, probably from the inferior dental artery.

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[1] Lancet, Dec. 1, 1860; see also Trans. of Path. Society of London for 1861, p. 159.

[2] Lancet, Jan. 21, 1882.

[3] New York Journal of Medicine, Oct. 1840.

[4] British Medical Journal, December 28, 1867.

[5] Medical and Surgical History of the War of the Rebellion, Part III., Surgical Vol., p. 649.

Necrosis of detached fragments, with loss of teeth, is a common consequence of severe fractures of the lower jaw. *Abscesses* often form, and may even prove fatal. Thus Mr. Abraham[2] exhibited to the Pathological Section of the Academy of Medicine in Ireland, a jaw fractured on the right side at the mental foramen, on the left side from behind the last molar tooth to the angle. The patient, a man aged 36, had been knocked down, and kicked while on the ground. "On the fourth day after the receipt of the injury he got out of bed, walked from his house a short distance, and returning fell dead at his own door. The fracture at the angle was found to be compound, communicating with the mouth; and an abscess traced from the parotid region down along the carotid artery into the pericardium, had formed in connection with it."

Richet,[3] in 1865, called attention to the occasional occurrence of putrid infection (*septicæmia*) as the result of fractures of the jaw with laceration of the alveolar periosteum, and Chassaignac stated that he had seen and published similar cases.

Salivary fistula is said to have sometimes occurred after compound fracture.

Treatment.—This may be a very simple affair, or it may require great mechanical skill and ingenuity on the part of the surgeon. Sometimes reduction is readily effected, and maintained with ease by bandaging; sometimes, although the fragments can be replaced without difficulty, they resume their faulty relation the moment they are left to themselves. Sometimes the obstacles to reduction are very great.

One case is recorded by Lonsdale,[4] in which a woman had the jaw fractured by a blow with a poker; "there was great difficulty in getting the two portions to lie in apposition, and the cause was not discovered till two or three days after the receipt of the injury, when, on passing a probe down, a tooth was felt jammed between the fractured surfaces; as soon as it was withdrawn, the ends of the bone came easily into contact." Sometimes splinters become wedged cross-wise between the fragments. I have already mentioned having had to divide the muscles just behind the symphysis in one case, in order to effect reduction; and my belief is that in very many cases, even with the best apparatus that can be devised, muscular contraction is not wholly overcome, but a certain degree—too slight it may be to produce obvious deformity—remains.

The great object to be aimed at is, so to restore the form of the bone that the teeth shall come into proper apposition with those of the upper jaw, and thus to insure to the patient the ability to masticate food. It is by no means always easy to judge of the degree of accuracy of the reduction, during the progress of the treatment; and the surgeon will do well as early as possible—say about the third week—to cautiously test the question by removing all apparatus, and, carefully supporting the broken bone below, bringing it up so that the line of the teeth, upper and lower, can be compared by means of the finger inserted into the mouth. Should there be any defect in the apposition, it may be much more readily corrected at this stage than at any later period.

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[1] New York Journal of Medicine and Surgery, January, 1857.

[2] British Medical Journal, December 23, 1882.

[3] Gaz. des Hôpitaux, 1865; Am. Journal of the Med. Sciences, July, 1866.

[4] Practical Treatise on Fractures, p. 229.

In effecting reduction, the surgeon should pass one or two fingers of one hand into the patient's mouth, applying them to the teeth, while with the thumb and fingers of the other hand he endeavors to bring the bone itself, at its lower border, into proper shape. As a general rule, the greater the violence which has caused the injury, the more will the bone be likely to be shattered, and the soft parts to be torn.

Fractures at or close to the symphysis are more easily kept reduced than those of the middle of the body at either side. And fractures at the angle are but little liable to displacement, partly because they are at the widest part of the pointed arch before spoken of, partly because the disposition of the muscles is such that neither fragment is pulled upon more than the other; they are as it were balanced.

The bandage most frequently employed in Philadelphia, in the retention of fractures of the lower jaw, is that known as Barton's.[1] Hamilton describes an apparatus made with straps and buckles, on a very similar plan, which he has used with satisfaction. Before applying either, it is better, if the patient be a male adult, to have the face shaved, or, at least, to have the beard clipped very short; the hair, if long, should also be cut.

If the fracture is at either side, it will readily be seen that the pressure of the bandage may be so exerted as simply to flatten out the broken bone, as it were; an action which, carried to excess, would produce between the fragments an angle salient toward the mouth. Hence it is much better to use a splint made of binder's board, felt, or gutta-percha, moulded to fit the chin, and smoothly lined with a thin sheet of raw cotton, or with Canton flannel.

Greater security may be given to this apparatus, if, before applying the bandage, the outer splint be fastened in place by a strip of plaster about an inch and a half in width, passing well up on each cheek. What is known as "rubber adhesive plaster" is the best, but any well-made adhesive plaster, not too fresh, will answer. If the strip be made twice as wide, and doubled on itself so as to have an adhesive surface toward the splint and another toward the bandage, the latter will be still further prevented from slipping. Such a precaution is by no means needless in the cases of some very unruly or delirious patients.

When the surgeon has any doubt as to the accurate retention of the fragments, a very simple and easy expedient may be adopted to insure it, at least until a permanent apparatus can be made. A large vial-cork may be cut down so as to square it on two opposite sides, leaving it of sufficient thickness for spaces to be cut out on these square sides, on one side for the upper and on the other side for the lower teeth. This shaping can be easily done with a sharp knife, by any one with ordinary dexterity in such matters. When finished, this *interdental splint* can be fitted to the upper teeth, the lower jaw brought up to it, and the fragments properly placed in their groove, after which the outside splint and bandage may be put on.

Another very ancient device is that of surrounding the adjacent teeth on the two fragments with a wire, which thus includes them in a loop, secured by twisting the ends of the wire. Such a loop need not be retained very long, and, indeed, ought not to be, lest it should injure the gums; a week or ten days will generally be a sufficient time, as the process of union will then have begun, and the fragments will be apt to keep their place.

In cities, or wherever the services of a competent dentist can be had, the best plan is to have a mould taken of the patient's jaws, the fragments being held in place by the surgeon. From this an accurate cast may be made, and upon this again a vulcanite plate, to fit above and below. When skilfully done, this gives the surgeon as absolute control of the fragments as it is possible to obtain. By some, splints of this kind have been attached to steel arms or branches coming out at the corners of the mouth, and connected with an outside framework, a padded plate fitting underneath the chin; when such an apparatus is employed, there is no need of the upper teeth being taken into the account at all, as the fragments are securely held between the mould above and the padded plate below. The arms connecting the two are arranged with screws and nuts, so that they can be tightened to the requisite degree.

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[1] See Vol. I. p. 494, Fig. 64.

Rutenick, Lonsdale, Gunning, Bean, Kingsley, and many others, have exercised much ingenuity in devising modifications of apparatus based upon this idea. The appliances known by their names may be found described in detail in so many systematic works, that it seems hardly worth while to devote more space to them here.

During the confinement of the jaw by any of the means now mentioned, it is obvious that the patient is debarred from the use of ordinary food; and by some of the older writers it was advised that a front tooth should be drawn in order to allow of the introduction of milk, soups, etc. This, however, is unnecessary; scarcely any one has the teeth so closely set together as to prevent liquids from finding their way to the back of the mouth. If from swelling or other cause deglutition be very much hindered, nourishment may be administered either by means of a tube passed along the floor of the nose, and so down into the stomach, or by enema. The difficulty of swallowing rarely persists more than a few days.

Suturing of the fragments has been practised with advantage in a few instances of very oblique fracture, where retention by ordinary means was found impossible. Kinloch's case,[1] the first of which I have any knowledge, was one of compound fracture, and the result was excellent. Thomas[2] has reported two cases attended with like success.

Fastening the fragments together, by means of silver pins, as recommended by Wheelhouse,[3] appears to offer no advantage over the ligature, while it multiplies the chance of irritation of the soft parts.

Fractures of the lower jaw are sometimes, but very rarely, complicated with luxation of one condyle. Probably the dislocation occurs first, as otherwise there would scarcely be purchase enough to force the condyle out of its socket. Details of the reported cases are given by Heath.[4] In one case only were both condyles displaced, and the necks fractured; and in one, in which only one condyle was luxated, it was also broken off at the neck.[5] Replacement of the condyle would, under such circumstances, be obviously impossible; but when the fracture is far enough from the condyle to give sufficient purchase, the luxation may be reduced in the ordinary manner, and the treatment of the fracture then proceeded with.

Non-union.—While, as a general rule, fractures of the lower jaw unite readily, there are not a few cases on record in which they have failed to do so. Malgaigne quotes from Bérard a curious case of "a child whose fracture made no progress toward recovery until the apparatus, an ordinary bandage, was removed." On a previous page a specimen of false joint formed at the angle was depicted; and Physick's case, in which union was brought about by the employment of a seton, is among the most widely-known instances of success by that mode of treatment.

But little need be said as to the course to be adopted when union takes place slowly, or when a false joint has formed, in fractures of the lower jaw, since the general principles already laid down are of particularly easy application here.

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[1] American Journal of the Medical Sciences, July, 1859.

[2] Lancet, August 17, 1867.

[3] Ibid.

[4] Op. cit., p. 22.

[5] Both these cases are quoted from Bonn by Coote, in Holmes's System of Surgery, 2d ed. vol. ii. p. 429; Am. ed. vol. i. p. 680.

In cases of slow consolidation, the surgeon should first have made a very accurately fitting interdental splint, and, after thoroughly rubbing the fragments together, he should apply it, so as to keep them at absolute rest in good relative position. Failing in this, he should proceed at once to drill the fragments, and wire them together, confining the jaw subsequently with a moulded outside splint and a carefully applied bandage.

When a false-joint has formed, the fragments may be at once scraped, drilled, and wired.

It will, perhaps, seem as if so prompt a resort to the most heroic measures, without a previous trial of milder means, were at variance with the accepted rules of surgery. But it must be remembered that this bone, though easily accessible, is very difficult of control; and that the interference with nutrition during the period required for such attempts, would be of itself a serious evil.

Union with Deformity.—When a fracture of the jaw has united with the fragments in bad relative position, it is very seldom that any means of correction are available; only, in fact, when the bone has been broken somewhere near the symphysis, as elsewhere interference would either endanger the vessel or nerve, or both, or would be useless by reason of the want of purchase for mechanical treatment. Yet it may be that in some few cases, even as far back as the angle, subcutaneous osteotomy might afford a chance of dividing the uniting medium, as it would indeed be the best means of doing it at any point. Afterward, drilling, wiring, and a well made interdental splint, with a bandage externally, should be employed.

FRACTURES OF THE LARYNGEAL APPARATUS.

FRACTURES OF THE HYOID BONE.—From its position and connections, this bone is greatly protected, yet a number of instances are upon record in which it has been broken, either alone or along with severe injuries of neighboring parts. It is of the former class of cases only that I have now to speak, since this lesion is in the others a comparatively unimportant complication.

Strange as it may seem, the hyoid bone is seldom fractured in cases of hanging, whether suicidal or judicial. Casper says[1] that he has never seen it in any of the numerous bodies officially examined by him. Mackmurdo, for many years surgeon to the Newgate Prison, in London, is quoted by Gibb[2] as stating that he had only once seen the body of the bone broken in a hanged man, and that in three or four only had he seen one or other cornu (never both) fractured. In suicides, the body of the bone was seen broken by Orfila, and a cornu by Dieffenbach and Cazauvieilh (two cases).

In the body of Wirz, hanged at Washington, D. C., in 1865, "the hyoid bone had received six injuries; separation of the greater and lesser processes on both sides from the body of the bone, and true fracture of the outer third of the greater process on either side."[3]

This bone has been several times observed to be broken by throttling (Auberge, Dieffenbach, Murchison, Lalesque, Devergie, Helwig), and by falls in which the front of the neck is struck against some resisting body (Harley,

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[1] Forensic Medicine, vol. ii. p. 174.

[2] On Diseases of the Throat and Windpipe, etc. London, 1864.

[3] Med. and Surg. Hist. of the War of the Rebellion, Part I., Surg. Vol., p. 400.

Gründer, T. Wood), and in three cases the lesion was ascribed to muscular contraction (Ollivier d'Angers, Obre,[1] La Roe[2]).

Ollivier's case was that of a woman, aged 56, who made a false step and fell, her head being thrown forcibly backward. "At the same moment she heard a very distinct crack at the upper part of the left side of the neck; there was a fracture of the greater cornu of the hyoid." La Roe's patient sustained the injury in yawning.

From the few recorded cases, the symptoms of this fracture would seem to be: sharp, sticking pain; sometimes spitting of blood; swelling, and embarrassment in speaking or swallowing; and, when the fragments remain in contact, crepitation. Upon examination with one finger in the mouth and one outside, the fragments can be felt, and perhaps pushed into place.

In Gründer's case, the only uncomplicated one which proved fatal, the broken cornu was found "jammed between the epiglottis and the rima glottidis." In all the other instances, there was union by means of callus; and this had taken place in two specimens, one without history,[3] and the other taken from a woman who several years before her death had received a blow on the neck by a heavy boot falling on her as she lay asleep.[4]

As to the *treatment*, the first point must of course be to remedy any displacement of the fragments, by manipulation; next to allay inflammation, by suitable local applications; to enjoin upon the patient perfect quiet, and to provide for his due nourishment, should swallowing be difficult or impossible, by means of nutrient enemata. A stomach-tube has been used in some cases, but at some risk of disturbing the fracture.

FRACTURES OF THE LARYNGEAL CARTILAGES.—The laryngeal cartilages are from their situation exposed to the same causes of fracture as the hyoid bone—compression by hanging or throttling, falls, and blows—but they are less under the shelter of the lower jaw, and hence more frequently suffer.

Casper[5] says that he has never yet seen fractures of the larynx in cases of hanging; but instances are recorded by Weiss and Cazauvieilh, and in the Warren Anatomical Museum, in Boston, there is a specimen of fracture of the right upper cornu of the thyroid cartilage from a Sandwich Islander, who took his own life in this way. A case in which the cricoid was broken by hanging is also recorded by Porter.[6] (In the official report[7] of the autopsy on the assassin Guiteau, it is stated that the thyro-hyoid membrane was ruptured, and that the hyoid bone and thyroid cartilage were widely separated.) Morgagni[8] says: "That the larynx is sometimes broken from that cause [hanging], I have seen, together with Valsalva." . . . "A hanged man had the sterno-thyroidei and hyo-thyroidei muscles torn, so that only a membranous substance remained in their place about the annular cartilage. And this very cartilage was also broken asunder." . . . "The celebrated Professor Weissius found, in a soldier who had been hanged, the annular cartilage broken asunder into many pieces, and the inferior part of the trachea entirely torn away from the larynx."

Malgaigne quotes cases of fracture of the thyroid cartilage, by the grasp of a hand, from Ladoz and Marjolin. Fractures of the cricoid cartilage alone, produced in the same way, have been reported by Fredet[9] and Pemberton.[10]

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[1] Gibb, op. cit.

[2] Medical Record, April 15, 1882.

[3] Gibb, Trans. of the Pathol. Society of London, 1862.

[4] Gurlt, op. cit., Bd. i. S. 327.

[5] Op. cit.

[6] Archives of Laryngology, June 30, 1880.

[7] Medical News, July 8, 1882.

[8] De Sedibus et Causis Morborum, Lib. ii. Epist. xix.

[9] Brit. and For. Med.-Chir. Review, Jan. 1869.

[10] Lancet, May 22, 1869. Mr. Pemberton refers also to papers on Manual Strangulation, by Wilson and Keiller, in the Edinburgh Med. Journal for 1855 and 1856.

Wales[1] reports a case of fracture of the thyroid cartilage and lower jaw by a fragment of a shell; Hamilton gives one case[2] of fracture of the thyroid and cricoid by a kick from a man, and another[3] by the kick of a horse. I have myself met with a case[4] of supposed fracture of the larynx (probably of the thyroid cartilage only) by the kick of a man.

Hunt records[5] an instance in which both the thyroid and cricoid were broken by a blow from a piece of wood thrown off from a circular saw. Perhaps the most remarkable case, however, is that reported by Sawyer,[6] in which there was double fracture of the lower jaw, with fracture of the hyoid bone, thyroid cartilage, right radius, and left patella; tracheotomy was performed on the fifth day, having become urgently necessary; the patient ultimately made a good recovery.

Instances have been reported by Maclean[7] and Roe,[8] in which the thyroid cartilage alone was broken by falls against resisting objects—a stump and the edge of a table. Sometimes the hyoid bone also suffers, as in a case recorded by Koch,[9] and in Sawyer's case above referred to; and sometimes, again, the cricoid is involved, as in the instance quoted by Malgaigne from Plenck.

Fractures of the cricoid alone by hanging and throttling have already been spoken of; Stokes records[10] an instance in which this lesion was the result of a kick.

The *mechanism* of production of these lesions is sufficiently apparent.[11] It does not seem that the rigidity of the cartilages has anything to do with their liability to fracture: Gibb[12] mentions a number of cases occurring in young children.

As to the *symptoms*, there is always more or less swelling of the parts, often increased by the occurrence of emphysema; in the case observed by me, there was a curious limitation of the emphysematous condition to the cervical region both anteriorly and posteriorly. Pain, increased by efforts at coughing or swallowing, is generally present, and is sometimes marked; there is always tenderness, and often the handling of the parts elicits crepitus. The voice is husky, perhaps almost extinct; breathing is difficult, and the face generally more or less livid, with an anxious expression. A very constant symptom is the expectoration of bloody, frothy mucus, with or without cough. From the presence of all or most of these phenomena, and the history of the case, a diagnosis may be arrived at without much difficulty.

The *prognosis* is a matter open to more doubt. In Plenck's case death was instantaneous, as it was also in a case of throttling reported by Damonetta;[13] but more frequently the patient dies gradually by suffocation, from hemorrhage beneath the mucous membrane, inflammatory swelling, or œdema. Roe, in the article before quoted, speaks of fracture of the cricoid as "almost invariably" fatal; and from the records it would seem as if he might have omitted the qualification. One case only has been reported[1] in which recovery is claimed to have occurred after lesion of this part of the larynx; I have seen a French translation[2] of the account, which is too vague, and apparently too inaccurate, to weigh against the mass of testimony on the other side. (Possibly this gloomy condition of affairs might be changed by the very early performance of tracheotomy). Unfavorable indications are, in any case: great interference with breathing, severe cough, marked cyanosis, and free spitting of blood. When recovery takes place, the voice is apt to be permanently altered.

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[1] Am. Journal of the Med. Sciences, Jan. 1867.

[2] Medical Record, Jan. 1, 1867.

[3] Fractures and Dislocations, 6th ed. p. 153.

[4] Reported in Archives of Laryngology, March, 1880.

[5] Am. Journal of the Medical Sciences, April, 1866. The reader may consult with advantage the table of 29 cases given at the close of Dr. Hunt's article.

[6] Ibid., Jan. 1856.

[7] Canada Med. Journal, Sept. 1865.

[8] Trans. of Am. Laryngological Association, 1880, p. 99.

[9] Quoted by Roe, loc. cit.

[10] Dublin Quarterly Journal of Medical Science, May, 1869.

[11] In the Index Medicus for 1882 (p. 380), there is given a reference to a paper by R. Haumeder, "Uber den Entstehungs-mechanismus der Verletzungen des Kehlkopfes und des Zungenbeins beim Erhangen," in the Wiener med. Blatt, 1882, S. 810. This probably embodies the latest views on the subject.

[12] Diseases of the Throat and Windpipe, etc., p. 436.

[13] Ann. des Mal. de l'Oreille et du Larynx, Mai, 1879.

As to *treatment*, anodyne fomentations and poultices, the latter made of light materials, may be used locally, to allay irritation. No compresses, or other confining apparatus, should be employed, as they would only still further embarrass respiration. Opiates may be given by the mouth if swallowing is not very difficult. Absolute silence and rest in bed should be enjoined, and a warm and moist atmosphere should be provided by the usual means. For a few days, at least, the patient should be fed by enemata.

I think that the invariable rule should be to contemplate from the very first the probability that tracheotomy may become necessary, and to arrange for its immediate performance should the breathing become increasingly difficult. No case of this kind can be safely left unwatched; and unless, as in a well-ordered hospital, aid can be instantly rendered in case of need, it would be the best practice to open the trachea at once, in anticipation of trouble.

Fractures of the Ribs, Costal Cartilages, and Sternum.

For a reason already stated, fractures of the vertebræ are given consideration elsewhere; and the subject now to be taken up embraces the fractures of the lateral and anterior portions of the wall of the thorax. In order to a full understanding of these injuries, the anatomy should be carefully studied, not only of the separate bones, but of the framework as a whole, and as covered in great part by muscular and other structures.

It will be seen that the seven upper ribs are attached, not rigidly, but nearly so, both posteriorly and anteriorly; the next three have in front a greater degree of motion, by reason of the length of the cartilaginous branches which run up to give them an indirect connection with the sternum; while the eleventh and twelfth are merely tipped with cartilage. Each rib has an angle, a curve, and a twist; and the mobility of the walls of the chest is the aggregate of that of all the constituent ribs. The sternum has a mobility dependent chiefly on the elasticity of the ribs and their cartilages.

Fractures of the Ribs.—The ribs may be broken by direct or indirect violence, or by muscular action. They are, in children, extremely elastic, and are not often fractured in them except by very great crushing force. Holmes[3] quotes the opinion of Coulon, that incomplete fractures of the ribs are very common in childhood. One case is mentioned by the latter author, in which a child, who died of rupture of the lung, was found to have sustained partial fracture of two or three ribs on each side. It is highly probable that in many cases in adults, supposed to be mere contusions, one or more ribs may have given way in a part only of their thickness. Mention has already been made of two cases of "willow fracture" of the ribs from gunshot, noticed during the late war.

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[1] In the Index Medicus for Aug. 1882, the reference is given as follows: "Masucci (P.) Su di un caso di frattura della cricoide, seguito da guarigione. Arch. Ital. di Laringol., Napoli, 1881–2."

[2] In the Revue Mensuelle de Laryngologie, etc., 1 Nov. 1882.

[3] Surgery, its Principles and Practice, p. 219, note.

Direct violence may affect only a limited area, and one rib only may be broken; or it may crush a large portion of the chest-wall. *Indirect violence* generally acts in the latter way. Blows with the fist or with weapons, falls against resisting objects, etc., are the chief direct causes of fracture in this region. Of indirect causes, one of the most frequent is the passage of a wheel over the chest; the caving in of earth, crushing under heavy falling bodies, and the pressure of crowds, have also been noted. Double fractures are not unfrequent.

An important difference obtains between the effects of these two forms of violence. Direct force is apt to drive the broken ends inward, so that the inner wall of the bone or bones gives way first, and is more extensively splintered; and, hence, injury to the pleura or lung is more apt to ensue, either as a primary or secondary effect. By indirect violence, on the other hand, the arch of the thoracic wall is bowed outward, and the fragments are caused to project.

For an obvious reason, when the ribs are broken by direct force, the line of separation is apt to be less oblique than when the fracture is due to indirect violence.

Fractures of the ribs by forces acting from without, are much more common in men than in women, the habits and occupations of the former involving more exposure to such causes of injury.

Muscular action has been observed as a cause of fracture of the ribs in a large number of instances. It is not easy to understand the mechanism of such lesions, unless we suppose that they are the result of a sudden pull by the extra-thoracic muscles, as by the serratus magnus (its lower part), the shoulders being fixed. Coughing has been the action to which these accidents have been most frequently due; the portion of the chest involved has been near or below the middle, and, whether from coincidence or not, almost always the left side. Thus Després[1] has recorded the case of a woman, aged 53, who broke "the eleventh left rib, four fingers' breadths from its junction with the cartilage," in a fit of coughing. Doit[2] reported a fracture of the sixth left rib in its anterior third, produced in the same way, the patient being a man, aged 59. Malgaigne mentions a case observed at the Hôpital Necker, in which "there took place in less than one month three successive fractures, affecting first the tenth, then the ninth, and, lastly, the eleventh rib."

One case is related by Castella,[3] in which a fracture of the ninth rib on the left side, was caused by sneezing. Gurlt quotes from Groninger a case in which the seventh and eighth ribs gave way in a robust man of 45, as he made a great effort to save himself from falling. Nancrede[4] records the case of a robust Englishman, aged 44, who sustained a fracture of the second rib on the right side, in an effort to straighten a scythe-blade.

Fractures of the ribs are rarely either compound or comminuted; they are very generally complicated with pleurisy, although this may be of very limited extent.

The chief *symptoms* of fracture of a rib are pain and difficulty of breathing, which are combined so as to constitute what is known as "a stitch in the side." The respiration is apt to be largely abdominal; as a rule, the patient can lie indifferently on either side. Cough, slight and suppressed, but constant, and troublesome from the pain caused by it, is very generally present;

[1] Gazette des Hôpitaux, 28 Fév. 1882.

[2] Med. Times and Gazette, May 6, 1882, from L'Union Médicale, 29 Avril.

[3] Ibid., Jan. 25, 1862, from Gaz. des Hôpitaux, 1861.

[4] Philadelphia Med. Times, May 23, 1874.

it has been suggested that it may be reflex, from the irritation of the intercostal nerves, which can scarcely fail to exist. Crepitus may often be elicited by merely placing the hand flat on the seat of injury, or by making alternate pressure on either side of it; or by placing the ear over the spot, and inducing the patient to take as long a breath as he can. Tenderness on pressure is a constant symptom.

When the lung has been punctured by one of the fragments, emphysema is very generally the result, air escaping into the subcutaneous areolar tissue. Of this Hammick[1] gives a very curious instance:—

> "A man was brought in for fractured ribs from the Glory, then lying in Cawsand Bay, and when the sailors uncovered him, it being night and very dark, they were astonished, for when they quitted the ship, immediately after he had fallen, he was a thin person, but from the escape of air into the cellular membrane, he was blown up to a frightful size—the scrotum being as large as his head—the breathing so laborious, and the symptoms so urgent that, without waiting to put him into bed, with a scalpel I freely incised several parts, particularly the scrotum; the escape of air was so great that it blew out a large candle held before it. By the next day there was only a little crackling feel in the neighborhood of the fractured ribs; he recovered finally from the injury, though it was many months before he could be discharged from the hospital."

The slight pleurisy, already mentioned as generally attendant upon fractured rib, may spread and assume such proportions as to endanger life; and pneumonia may be superadded to it.

The *prognosis* is, of course, grave, if the injury is very extensive; yet Holmes[2] says he has seen a young woman recover from fracture of every rib in the body, and comminuted fracture of the left clavicle involving such damage to the brachial plexus as to cause permanent paralysis of the arm.

Injury to the vessels, or to the viscera, adds very greatly to the danger. Turner[3] has recorded an instance in which a robust man, fencing with another in sport, was struck with a light cane over the eighth rib on the right side, and died from rupture of the intercostal artery, five pints of blood being found in the pleura.

Wounds of the heart are not infrequent. Lonsdale[4] gives an account of a man, aged 21, run over by a wagon-wheel, in whom the following condition was found after death:—

> "Eight ribs of the left side were fractured at their posterior part, about an inch from their tubercles; and the four middle ones were broken at the anterior part as well, causing a double fracture. The pericardium was filled with blood, and a large quantity had escaped into the chest as well. The left auricle was found to be torn by the fractured ends of the ribs having been thrust against it."

Eve[5] quotes from Lees a very singular case:—

> "A brewer's man had fallen under a dray, when it was heavily laden, which passed over his chest; he was lifted up and complained of pain and weakness, but was able to continue sitting on the side of the dray, driving the horse for nearly an hour, when being in the vicinity of the hospital he thought he might as well get himself examined; he walked in and lay on a bed, but on turning on his side he suddenly expired. On dissection it was found that the fifth rib was fractured, and that the extremity of one portion had penetrated the pericardium, but had freed itself from the heart; and this, as Mr. Wilkin observes, accounts for the sudden death of the man. For it is probable that the portion of rib had filled up the wound of the heart, and thus prevented any hemorrhage until his arrival at the hospital, when, on its coming out, the sudden effusion of blood into the pericardium caused death."

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[1] Op. cit., p. 163.

[2] Op. cit., p. 218.

[3] Med. Times and Gazette, Dec. 22, 1860.

[4] Op. cit., p. 258.

[5] Remarkable Cases in Surgery, p. 221.

Hammick[1] mentions a case in which a man was struck on the side by the end of a flying rope, and died immediately:—

The post-mortem showed that "one rib only had been broken, both ends of which had been driven inward, piercing the very apex of the heart, penetrated both ventricles, and then had returned to their situation by their own elasticity; the pericardium was full of blood, but none had escaped into the chest."

Hammick suggests that death was due here to the shock to the diaphragm or to the heart; but it seems as if the escape of blood into the pericardium might amply account for it.

Still another case may be cited, reported by West:[2]—

A young man fell into a coal-pit, and was taken out dead. There was no wound on the surface; but the sternum was broken into two fragments, and the third, fourth, fifth, sixth, and seventh ribs on the left side were fractured also. The pericardium and pleura were full of black fluid blood, and both right and left ventricles of the heart extensively lacerated.

Fractures of the ribs generally unite without difficulty, in the simpler cases; but from the unavoidable mobility of the parts there is apt to be some excess of callus. When several ribs are involved this condition is more marked, and sometimes—as in a specimen in the Wistar and Horner Museum of the University of Pennsylvania—there are curious stalactitic prolongations from each bone at the fractured part, as if the plasma had been pulled upon and drawn out when soft.

Non-union is sometimes met with:—

Boardman[3] found in a colored girl, aged 22, a fracture of the eighth right rib, of three or four months' standing, ununited, and the fragments carious; a fistulous opening led into the pleura, which was coated with lymph and contained about two pints of pus. On the left side, the eighth rib was also broken, and there was an abscess between the intercostal muscle and the pleura, pointing within, and apparently ready to burst. This latter lesion was only discovered after death; the other was attributed to a kick.

The *treatment* of fractured ribs, when uncomplicated with lesions of the internal structures, consists simply in immobilizing the parts; and this is best done by means of adhesive strips, as first recommended by Hannay.[4] It had been previously effected by the application of bandages, either ordinary wide rollers, or broad strips of flannel or muslin pinned about the chest. At the present day, the adhesive plaster is in very general use; it is cut into strips from eight to sixteen inches long, according to the size of the chest, and about an inch and a half in width. These are put on very firmly, parallel with the ribs, and overlapping one another from above downward, each one covering about one-third or one-quarter of the width of the preceding one. By Erichsen and others it is advised that the strips should surround the whole body; but this will be found to impede respiration and give trouble. It is better to let the strips extend no further than the median line in front and at the back. Before applying the plaster, any marked displacement of the fragments should be corrected by suitable pressure and manipulation, the patient being directed to fill the chest as much as possible during these attempts. My own practice is to apply the strips during expiration; and the pain caused by the act of breathing ought to be markedly relieved. When the fragments project outward, a compress of lint, not too thick, may be placed over the angle before the plaster is put on. When they are driven inward, two compresses may be employed, at such points as to tilt up the ends and take off the pressure upon the parts within. Operative interference for the purpose of prying up a fragment by means of the finger, a lever, or a blunt hook, inserted through an incision of the skin, has been suggested. Malgaigne mentions "removal of a piece of rib" as having been resorted to by Soranus and by Rossi; but these, I believe, are the only known cases of the kind. He proposes the use of a hook curved like a tenaculum, inserted over the upper border of the bone; and if the hook were blunt this could readily be done without wounding the pleura. Such a procedure could, however, very rarely be called for.

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[1] Op. cit., p. 165.

[2] St. Thomas's Hospital Reports, N. S., vol. i. 1870.

[3] Proceedings of the Pathological Society of Philadelphia, vol. ii. p. 130.

[4] London Medical Gazette, November, 1845.

Should the fracture involve several ribs, I believe advantage would be gained by the use of a short, thin slip of wood, properly covered, and applied across the posterior portions of the ribs, so as to act as a splint as well as a compress, pushing the fragments outward, away from the pleura and lung. It might of course be held in place by adhesive plaster, put on in the manner above directed.

When a bandage is used, it is best made of flannel, about three inches wide; if cut obliquely, or "bias," it will be much more elastic than if torn lengthwise of the piece. One or two turns round the shoulders will prevent it slipping downward, and a few strips of adhesive plaster across it on either side (not in front), running down as far as the pelvis, will keep it from slipping upward.

Emphysema generally disappears of itself, without treatment. As to complications from intra-thoracic inflammation, they must be dealt with on the principles laid down in works on the practice of medicine. I may, however, say that leeches, applied just at the seat of injury, or cups in its immediate neighborhood, have sometimes seemed to me to be of great service. General bleeding I have never had occasion to employ in cases of this kind.

Internal hemorrhage, in the recorded cases, has usually been speedily fatal, and it is seldom, if ever, amenable to treatment. Should opportunity be given for the employment of remedies, ergot and acetate of lead would be indicated, and advantage might be derived from the external application of cold.

In any case of injury of the chest, when fracture of one or more ribs is suspected, but cannot be clearly made out, it is safer to adopt the same course that would be followed if the bone were proved to have given way. The enforced rest will be beneficial if there is mere contusion, and still more so if there is really an undetected fracture.

FRACTURES OF THE COSTAL CARTILAGES are very rare, and not always easily distinguishable from separations at the junction of the cartilages with the ribs. They are apt to be nearly transverse, and are generally due to direct violence.

Reed[1] has reported the case of a man, kicked by a mule, in whom there was separation of the sternum at the junction of the first and second pieces, with fractures of the cartilages of the second, third, fourth, and fifth ribs on the right side, as well as of those of the second, third, and fourth ribs of the left side. The pleural cavities were filled with blood. The right clavicle was also fractured. This extensive injury produced no sign until tympany came on (from rupture of the spleen), and the respiration became of necessity thoracic, with crepitus and displacement of the fragments.

A man was brought to the Pennsylvania Hospital in 1855, who had fallen from a wharf, striking his chest on the edge of a boat. After his death from peritonitis (the colon having been ruptured), it was found that the sixth and seventh cartilages on the right side were fractured about an inch from the sternum; the perichondrium was entire in the sixth, but torn anteriorly in the seventh.

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[1] Proceedings of Path. Society of Philadelphia, vol. ii. p. 47.

M. Broca[1] is reported to have mentioned to the Société Anatomique a case in which the sixth, seventh, and eighth cartilages on the right side were fractured by muscular action. The patient, a porter, had a sack of peas on his shoulder, when another sack was suddenly laid upon him. The weight bore him forward, and in raising himself against it he sustained the injury, the result of which is not stated.

Gurlt quotes from Chaussier the case of an officer, aged 48, who had a diastasis of the cartilage of the left upper false rib, produced by a fit of coughing; there was a hernia of the lung as large as a hen's egg. He cites also Monteggia's account of a very thin man, aged 70, in whom the cartilages of the second and third (true) ribs had been separated from the ribs themselves, also by coughing.

When these fractures do not prove immediately fatal by reason of the damage involved to the thoracic viscera, they may heal like other lesions of the same kind in other parts. Sometimes, however, they result in serious impairment of respiration, and consequently of the general health. Of this the following case affords a good example:—

A cavalry officer[2] was injured in the right side by a fall from his horse, in July, 1864. Three months later his case was reported as "fracture of the ribs, which have not yet united." In 1870, he was examined by a pension surgeon, who certified that "the sixth and seventh ribs on the right side were fractured and dislocated from the sternum, and, not being properly adjusted, an imperfect cure was the result. There is a projection of two inches outward from the chest at the ends of those two fractured ribs, which are not joined to the sternum. The muscles which move the arm are weakened, and exercise causes pain." Seven years afterwards, it was noted by an examining board that the pensioner had "an anxious expression of countenance; distended nasal alæ; respiration easily disturbed; loud resonance and weak respiration in right lung, indicating emphysema."

Macleod[3] mentions the case of a man "hit by a round shot on the edge of the breastplate, which was so turned inward as to fracture the cartilages of the fifth, sixth, and seventh ribs on the left side, close to the sternum. The skin was not wounded. He walked to the rear, and complained but little for two hours, when he was seized with an acute pain in the region of the heart. His pulse became much accelerated, and he grew faint and collapsed. A distinct and sharp bellows-sound accompanied the heart's action. He died in seventy-two hours from the receipt of the injury, the pain and dyspnœa, which had been so urgent at first, having abated for some hours before death. The heart was found to have been ruptured to an extent sufficient to allow of the finger being thrust into the left ventricle. The obliquity of the opening had prevented the blood escaping into the pericardium, which contained about two ounces of dark-colored serum."

From the cases now quoted, it will be perceived that the injuries in question have much in common with fractures of the ribs.

Union takes place, according to Gurlt, by the formation of spongy bone around both fragments, or in the interspace between their outer walls, the broken ends remaining quite passive.[4] A number of specimens exist in various museums illustrating this. Gurlt says, on the authority of Malgaigne and Klopsch, that in dogs and rabbits the divided cartilages unite by fibrous or fibro-cartilaginous substances; but that in large animals, as in the horse, the rule is the same as in man.

The *treatment* must be immobilization by means of adhesive plaster. Malgaigne recommends an instrument like a truss, having a spring carrying two pads, one to be applied over any projecting fragment, the other at the back, and mentions a case in which he employed this apparatus with success.

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[1] Brit. and For. Med.-Chir. Review, Oct. 1856.

[2] Med. and Surg. Hist. of the War of the Rebellion, Part III. Surg. Vol., p. 649.

[3] Notes on the Surgery of the War in the Crimea, etc., Am. ed., p. 204.

[4] Interesting and instructive articles on this subject, by Prof. Bennett, may be found in the Dublin Journal of Medical Science for March, 1876, and for October, 1877.

Fractures of the Sternum.—From the spongy structure and exposed situation of this bone, one might expect that it would be very readily broken. Yet such is not the case; it is not often fractured, and very rarely by direct violence. When this does happen, other bones in the neighborhood are apt also to be involved. A good many instances, however, are upon record in which this bone has given way to indirect force, and to muscular action.

A longitudinal fracture of the sternum, produced in a mason who was buried under some heavy stones, was recorded by Barrau, and is quoted by Malgaigne and Gurlt; it is the only undoubted case of the kind, as far as is known. Gurlt quotes two instances of partial fracture of this bone, the posterior surface alone having suffered; hemorrhage had taken place into the mediastinum in each. One, seen by Senator, was from the kick of a horse; the other, by Brotherston, from a fall of about ten feet upon the head.

The following curious case is mentioned by Malgaigne:—

> "A man of sixty-three was knocked down by a dray, the wheel of which went up on the left side of the chest, but not getting over the trunk, passed off on to the left arm, which, however, was uninjured. The next day the man came to the hospital; a quite notable swelling occupied the upper sternal region; and the first piece of this bone, with the cartilage of the second rib on each side, made so marked a prominence in front that I thought I had to deal with a luxation, or with a transverse fracture with overlapping. I tried various manœuvres to accomplish reduction, but in vain; effusion occurred in the pleura; an abscess formed above the fracture, and the patient succumbed on the thirty-third day. At the *autopsy*, fractures were found in the semi-ossified cartilage of the first rib on the left side, as well as in the second, third, and fifth ribs of the same side; these had not been suspected at all. The sternum was broken transversely at the level of the third intercostal space, the upper fragment being slightly inclined backward; this fracture also had escaped notice. Lastly, a fracture, situated above and to the left, detached from the bone, as if with a knife, a sort of scale, the base of which reached from the fourchette to the level of the second costal cartilage, comprising all the left sterno-clavicular articulation, and the cutting edge of which was at the anterior face of the bone; the abscess had formed at the seat of this fracture."

Malgaigne quotes from Duverney a case in which a ten-pin player, who bent forward to watch his ball, fell, striking a large stone; he was taken up dead, with a fracture of the sternum. I must say that this account is not full enough to be satisfactory, as some other lesion must have been present. Gibson[1] says that, in 1839, he saw in the museum of the London University a heart, the right ventricle of which had been lacerated by a fractured sternum; and he cites a like case from Sanson.

A number of instances are on record in which fracture of the sternum would seem to have been caused by the impact of the chin, the vertebræ giving way and allowing the head to be forced forward and downward. Four such cases were observed by Hodgen;[2] in three of them the patients had fallen backward, striking on the shoulders. Rivington[3] mentions a case in which—

> "An acrobat, æt. 30, in turning a double somersault, fell about ten feet on to the back of his head. He came down on some tan, and his head was violently flexed on to his chest. The injury caused a separation between the sixth and seventh cervical vertebræ,

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[1] Op. cit., p. 253.

[2] Holmes's System of Surgery, Am. ed., vol. i. p. 752.

[3] British Medical Journal, January 31, 1874.

and an oblique fracture of the sternum, such as might have been produced by the chin inclined to one side."

Michael[1] records the case of a seaman who fell into a hold, sustaining a dislocation of the fifth cervical vertebra on the sixth, with fracture of the sternum, the periosteum remaining unruptured in front. Spontaneous reduction of the luxation took place. There was laceration of the lung, and the mediastinum became emphysematous. Death occurred on the third day.

In all the foregoing cases the fracturing force acted directly. Indirect violence may be exerted in either one of several ways: by the forcible bending backward of the trunk, or by falls on the buttocks or on the feet. Malgaigne suggests that some of the fractures ascribed to muscular contraction are really due to the first of these causes—a forcible separation of the upper and lower ribs, carrying with them their respective portions of the sternum. But in all cases, I think, we may exclude the direct pull of the muscles attached to the sternum as causes of its fracture. Gross[2] gives the following account:—

"In 1838 I attended, along with Dr. Rohrer, a case in a large, heavy, muscular man, forty-six years of age, who had received a transverse fracture of the upper part of this bone, from inordinate contraction of the sterno-cleido-mastoid muscles, in jumping, in a state of intoxication, off a shed eleven feet high. The heels striking the ground obliquely, threw the body violently backward, the head and neck coming in contact with the edge of a board. The fracture was, doubtless, occasioned by the effort which the man made to regain his equilibrium."

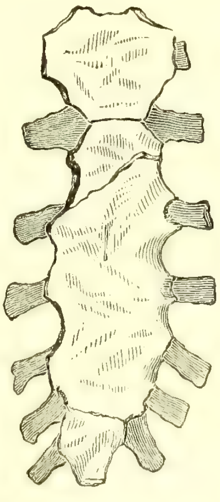
My own belief is that here there was sudden flexion of the body backward, and that the fracture was due to the mechanism before spoken of.

A number of instances have been known in which the sternum has given way to powerful muscular contraction in child-birth. In all of them, as far as I know, the trunk is stated to have been bent strongly backward. Analogous to these cases would be that often quoted from Faget, in which a mountebank, as a feat of strength, was leaning back and trying to raise a weight with his teeth. When the great extent of muscular structure, connected with the ribs, which would thus be put into forcible play, is considered, it can scarcely be doubted that to this, and not to the mere contraction of the muscles attached to the sternum alone, should the production of the fracture be ascribed.

It is not always an easy matter to determine whether the lesion is an actual fracture, or merely a diastasis between the pieces of the sternum; but the question is not one of great practical importance. Occasionally, as in the specimen[3] of which Fig. 597 is a representation, the line of fracture clearly runs across one portion of the bone, with a marked degree of obliquity.

Sometimes the displacement is very slight, but it may be considerable; and, in the great majority of cases, the lower fragment projects in front of the upper. Malgaigne mentions one case seen by Sabatier, in which an old man had been subjected to great violence, and thrown into a hole thirty feet deep. He fell on his

Fig. 597.



Fracture of sternum.

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[1] Maryland Med. Journal, Sept. 1, 1882.

[2] Op. cit., p. 956.

[3] In the Mütter Museum of the College of Physicians of Philadelphia; the specimen has no known history.

back; the second piece of the sternum was broken away from the first, and driven in behind it.

The *symptoms* of this injury are analogous to those of fractures of the ribs and their cartilages. Pain, tenderness, swelling, and ecchymosis have been noted in all the cases not immediately fatal. Cough almost always occurs, and emphysema may exist independently of injury to the lung. Displacement and crepitus have generally been more or less distinctly marked. Suppuration has occasionally taken place in the anterior mediastinum.

Riedinger[1] says that repair, when it ensues, is effected by means of a layer of fibro-cartilaginous material, placed between two other layers of hyaline cartilage. Very probably this statement may apply to cases of disruption occurring between two of the pieces; but when a true fracture takes place in this bone, it is repaired in the ordinary manner, as may be seen in many museum specimens.

The *treatment* of these injuries does not differ in any material respect from that of fractures of the costo-sternal cartilages. When displacement exists to any marked degree, it should be corrected as far as possible. But while it is eminently proper to make this attempt, it must be remembered that the displacement is not of itself a source of danger. Hammick[2] says that "if the bone were allowed to remain depressed, it would extinguish life;" but there is no ground for this statement. Hence operative interference, such as the introduction of gimlet-like screws, or of elevators or blunt hooks, for the purpose of pulling or prying up the depressed fragment, is unjustifiable. Moreover, the texture of the bone is too spongy to afford a good hold to such instruments. The only available method of procedure is to act upon the lateral walls of the chest, by causing the patient to alternately fill and empty the lungs to the fullest extent possible to him, and by raising and lowering the arms, while the surgeon tries to push in the projecting fragment.

The deformity having been thus rectified as far as may be practicable, the walls of the chest should be immobilized by means of adhesive strips, applied across their anterior portion, and covering in the whole sternal region. A flannel bandage surrounding the whole thorax may be put on in addition to the strips, and secured so that it shall not slip upward. Should inflammatory or other complications arise, they should be met by appropriate treatment. Absolute rest in bed should be enjoined, and a concentrated diet.

When an abscess forms behind the sternum, if its presence can be clearly made out, there is no positive objection to penetrating the bone in the median line with the crown of a small trephine; but it is almost certain that the pus will find its way to the surface, either at the seat of fracture or in one or more of the intercostal spaces, when vent can be given to it by a simple puncture of the skin.

FRACTURES OF THE PELVIS.

Viewed as a whole, the pelvis constitutes a bony ring, interrupted anteriorly by the pelvic synchondrosis, and posteriorly on either side by that between the sacrum and the ilium. These synchondroses, by the arrangement of the walls and cancellous structure on either side of them, are adapted to diminish the stress put upon the whole framework, either by ordinary or by extraordinary forces. It may further be said that the pelvis presents not only the bony ring just mentioned, which has no great depth below the brim of the lower or true pelvis, but also certain appendages—the iliac expansions above, the rami of the pubis and ischium below and on either side, and the downward prolongation of the sacrum and coccyx behind. The ligaments which bridge across the gaps between these appendages add nothing to the security of the bone against fracturing forces. Of the whole framework, the strongest part is that where, in the erect position, the weight of the trunk is transmitted to the head of the femur; the sacrum, although thick, is composed in great measure of spongy bone, further weakened by the perforations for the sacral nerves, as well as by the terminal portion of the spinal canal.

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[1] Gaz. Méd. de Paris, 12 Août, 1882.

[2] Op. cit., p 167.

Fracture of the pelvis is not common in men, is rarely met with in women, and is almost unknown in children. The youngest patient I remember to have treated for such an injury was sixteen years old. Bryant, however, mentions two cases seen by him in children, and a few others are upon record. I may mention here that, notwithstanding the rarity of fractures of the pelvic bones, three cases were under treatment at one time in my wards at the Episcopal Hospital, in 1882; a sort of coincidence not unfrequently met with in practice.

Fractures of the appendages may occur without affecting the continuity of the pelvic girdle proper. They are generally due to direct violence. Thus the crest of the ilium may be broken off, in one or more pieces; the lower part of the sacrum may be fractured more or less transversely, or comminuted; or a portion of the ischium may be separated, this, however, being very rare. The lines of fracture vary almost indefinitely, as might naturally be expected.

When a crushing force, such as the caving in of a mass of earth, a fall of rock or of coal in a mine, or the passage of a heavy wheel over the lower part of the body, is brought to bear upon the whole pelvis, the bone may give way at two or more different points. One or the other side of the ring may be especially acted upon, or the stress may be exerted directly across, either antero-posteriorly or laterally. In any case, however, the pubis would seem to yield first, in its horizontal ramus, when there must be a fracture also somewhere between the symphysis pubis and the tuber ischii. Next, if the force acts antero-posteriorly, the tendency will be to open out the lateral arc of the bone, which may be broken at or near the sacro-iliac junction. Thus a portion of the sacrum may be torn away, or the lesion may be confined to the os innominatum. Cases of the former kind have been very fully discussed by Voillemier, in two instructive papers.[1] According to him, vertical fractures of the sacrum very generally belong in the category of "fractures par arrachement," or what we should now call "sprain-fractures." That is, by the immense strain brought to bear upon the pelvic ring, the sacro-iliac synchondrosis being too strong to yield, the spongy substance of the sacrum is actually torn across.

The mechanism above described is regarded by Tillaux[2] as that which uniformly prevails in the production of these fractures; and his view is supported by the fact that in all cases of multiple fracture of the pelvis (and there is no portion of the skeleton so liable to this form of injury), the anterior segment of the ring suffers. The annexed cut (Fig. 598), taken from a specimen (without history) in the Mütter Museum, will give a good idea of the usual characters of this fracture.[3]

A few years ago I saw a case in which double fracture of the pelvis had been produced by lateral pressure in a somewhat curious way. The man was sitting in the side window of the "cab" of a locomotive, leaning forward with his buttocks projecting, when it passed through the narrow door of an engine-house, and he was caught and jammed. After his death, it was found that the bone had given way on each side.

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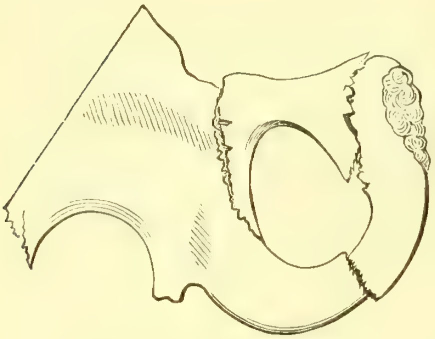
[1] Clinique Chirurgicale, pp. 77 et 107.

[2] Traité d'Anatomie Topographique, p. 829.

[3] Kusmin, in an article to which I have not been able to obtain access (Ueber Beckenfrakturen, Centralblatt für Chirurgie, Jan. 6, 1883; from Wiener med. Jahrb., 1882), gives the results of experimental researches on the mechanism of the production of these fractures.

Fig. 598.



Multiple fracture of the pelvis.

Occasionally, fractures of the pelvis have been seen as the result of falls on the feet, and even from much slighter accidents. Thus Bouvier[1] recorded the case of a man, aged 71, who met with a slight fall out of bed, and fractured the left os innominatum, from the ilio-pectineal eminence, down through the acetabulum to the spine of the ischium.

Sometimes the force acts directly through the head of the femur upon the adjacent portion of the os innominatum. Hutchinson[2] records an instance of starred fracture of the acetabulum, the head of the femur being driven through it by a fall on the trochanter. Gama[3] reported the case of a man, aged 30, who fell eighteen feet, striking on the trochanter. Death occurred from peritonitis on the tenth day. At the autopsy it was found that there was an abscess extending from the hip to the calf of the leg, and into the iliac region within the pelvis; the acetabulum had been broken into three pieces, the smallest of which was placed with the round ligament upon it, and unbroken, on the head of the bone; the second was the horizontal ramus of the pubis, which was separated from the symphysis pubis and ischium; and the third was the ischium, which was no longer connected with the ilium. Perhaps the most remarkable case is that recorded by Lendrick,[4] in which, by an accident many years previous, the head of the femur was found to have been driven through the acetabulum, and to be covered in, partly by bone, partly by fibrous tissue; the os pubis had been fractured and united with shortening, entangling a portion of intestine, which remained within a bony cavity as a sort of hernia; the ischium also had been fractured and united.

It not unfrequently happens that the anterior portion only of the pelvis suffers, perhaps at numerous points. Lodge[5] saw six fractures thus located, as the result of the caving in of a bank of earth upon the patient; and Peaslee[6] a case in which seven fractures had been caused by the patient being jammed in a narrow space between a railroad car and a platform. Rupture of the bladder had occurred in both cases.

In one instance, reported by Letenneur,[7] it was claimed that fracture of the pubis had been caused by muscular action; the patient, a woman, was lifting some large stones in unloading a boat, and felt something give way; but as it is expressly stated that, at that moment, she rested a stone, weighing over one hundred and fifty pounds, on the pubis, there must at least be some doubt whether the fracture might not be more justly attributed to the direct pressure thus exerted. Coates[8] has recorded a case in which the os pubis was fractured in a very analogous way, a coach in which the patient was travelling having been overturned, and the anterior part of her pelvis having been forced against the seat by the weight of several of the other passengers thrown over upon her.

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[1] Am. Journal of the Med. Sciences, February, 1839.

[2] Med. Times and Gazette, February 24, 1866.

[3] American Journal of the Medical Sciences, May, 1838, from Gaz. Méd. de Paris.

[4] London Medical Gazette, March, 1839.

[5] Am. Journ. of the Med. Sciences, Oct. 1865.

[6] Ibid., April, 1850.

[7] Medical Times and Gazette, November 28, 1868.

[8] Med.-Chir. Trans., vol. xi.

Fractures of the Acetabulum.—Fractures of the *rim of the acetabulum* are by no means uncommon; they owe their importance chiefly to the fact that they are apt to allow the head of the femur to slip out of place, and, although it is easily reduced, it escapes again with equal readiness. A number of instances of this kind are given by Sir A. Cooper,[1] one of which, observed at St. Thomas's Hospital in 1791, is, I think, the earliest on record. McTyer[2] published several cases; R. W. Smith,[3] one; Lonsdale, one; Holmes,[4] one; Eve,[5] two; Gurlt[6] gives a wood-cut, representing a fracture of the upper part of the rim of the acetabulum, which allowed of a very curious luxation—the trochanter major lying in the acetabulum, and the trochanter minor being applied to the outer edge of the tuber ischii.

Favell, in an address before the British Medical Association,[7] detailed a case which occurred under the care of Mr. Wheelhouse, in which a fracture of the rim of the acetabulum gave rise to subsequent dislocation of the femur upon the dorsum ilii—the symptoms of the latter lesion being manifested only some months after the accident, when the patient got up and bore his weight on the limb. The case became the subject of legal proceedings, but the result is not stated. Morris[8] has reported an instance of unreduced dorsal dislocation of the femur, with fracture of the rim of the acetabulum, in a young and active man, the displacement coming on gradually during a period of about ten weeks.

The mechanism of this fracture must be sufficiently obvious.

Fracture of the Sacrum.—Fracture of the *sacrum* by itself is not of common occurrence, although the spongy character of this bone, before spoken of, renders it really the least resistant portion of the pelvis; and occasionally violence is applied to it directly. Lee[9] has recorded the case of a man in whom, by a fall from a height of forty feet, the sacrum was broken across; the displacement of the lower fragment forward was corrected by means of a finger in the rectum. At the autopsy, "the sacrum was found comminuted, a large fragment of the left ala being broken off longitudinally and displaced to a considerable extent."

In a very remarkable case reported by Burlingham,[10] the patient, a railroad conductor, was thrown into the air, fell on the top of a car, striking on his back, and then rolled down an embankment a distance of over eighty feet. He sustained a compound fracture of the sacrum, the posterior surface of the bone at least being comminuted; and through the wound in the back, urine flowed for many months.[11]

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[1] Dislocations and Fractures of the Joints, 6th ed. London, 1842.

[2] Glasgow Medical Journal, February, 1831.

[3] Archives Gén. de Médecine, 1838.

[4] Transactions of Pathological Society of London, vol. xi., 1860.

[5] Med.-Chir. Transactions, vol. lxiii., 1880.

[6] Op. cit. Bd. i., S. 320.

[7] British Medical Journal, August 5, 1876.

[8] Lancet, February 18, 1882.

[9] Proceedings of Pathological Society of Philadelphia, vol. ii. p. 116.

[10] American Journal of the Medical Sciences, April, 1868.

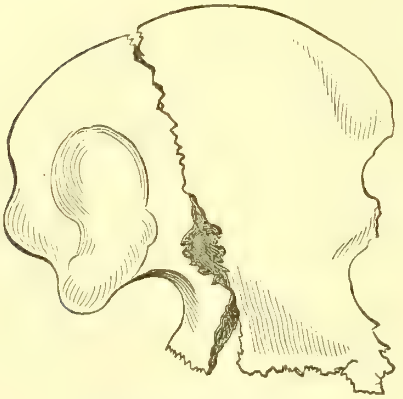
[11] In the account of this case, it is stated that about three weeks after the accident "a probe could be passed from about an inch above the base of the coccyx, and about three-quarters of an inch to the right of the median line, across the pelvis, forward and slightly downward, a distance of five inches, until it was obstructed by bone, denuded or fractured." This fact, taken together with the injury to the bladder, seems to me to indicate that a fracture had occurred anteriorly also; but, as the patient recovered, the diagnosis could not be placed beyond doubt.

Fracture of the coccyx is spoken of by authors; but the consolidation of the several pieces takes place only in advanced age, and without this a true fracture could scarcely occur. No unquestionable cases are upon record in which this bone alone has been broken, and the probability is that the lesion involved to the surrounding soft parts would be of far more importance. Should trouble arise in any such cases from inflammatory thickening and contraction of the tissues, it would be proper to divide the latter with the knife; and failing relief from this, excision of the bone might be practised, although the experience recorded by Mursick[1] is not such as to warrant great expectations of success.

A case is reported[2] in which the coccyx, "fractured and standing at a right angle with the sacrum," was removed by means of the "surgical engine," by Dr. Garretson. The history given of the case is simply that the patient, a lady, had suffered from coccygodynia for thirteen years. The periosteum was incised and laid open so as to expose the bone, which was then drilled away. The ultimate result is not stated.

Fracture of the Crista Ilii.—Fracture of the *crest of the ilium* is by no means uncommon. I have seen it caused by a fall from a horse, the patient striking on his hip against some railroad iron piled at the side of the street. At the Episcopal Hospital, in 1882, I had in the wards a man aged 21, who had fallen about twelve feet, striking on a rafter; the left crista ilii, from near the sacrum to a point near the anterior superior spinous process, was broken off. In this case there was, for some weeks, severe pain along the course of the anterior crural nerve; and it seemed probable that its trunk had been pinched or torn.

Fig. 599.



ꓕ-fracture of the ilium.

A rarer form of fracture of the ilium is shown in Fig. 599, taken from a specimen (without history) in the Mütter Museum. The bone has been separated nearly vertically, and transversely as well, the two lines of fracture representing an inverted ꓕ.

Hamilton states that he has seen about three inches of the ilium, including the anterior superior spinous process, torn off by muscular action; the patient, a man aged 70, having merely risen from his seat in a railroad car, when he felt "something wrong." Riedinger[3] claims that muscular action plays a much more important part in the production of fractures of the pelvis generally than has been ascribed to it by most writers.

Fractures of the ischium alone are very rare, the six cases collected by Malgaigne being the only ones known. Three of them were due to violent falls on the buttocks, and all to direct violence.

Malgaigne has devoted a special section to what he calls "*double vertical fracture* of the pelvis." This he defines as "a combination of two vertical fractures, separating at one side of the pelvis a middle fragment comprising the hip-joint; according as this fragment is carried upward or inward, the femur follows its movements, and hence result changes in the length and direction of the limb which have often misled practitioners." An injury of this kind might readily be mistaken, at first sight, for fracture of the neck of the femur, as there would be crepitus, some degree of shortening—although in one case, according to Larrey, there was lengthening—of the limb, and very probably impairment of motion; certainly inability to walk or stand. Careful examination, however, into the precise seat of the crepitus and difficulty of movement would, in most cases, be apt to reveal the true nature of the lesion.

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[1] American Journal of the Medical Sciences, January, 1876.

[2] Philadelphia Med. Times, February 11, 1882.

[3] Arch. für klin. Chirurgie, Bd. xx. Heft 2; American Journal of the Medical Sciences, April, 1877

Besides the fractures of the various portions of the pelvis which have been enumerated, there are certain cases of more extensive injury in this region, the whole framework being broken up, as in some mining accidents. I have seen the os innominatum on either side broken through nearly or quite vertically, both anteriorly and posteriorly, making four principal fragments. Such injuries are in themselves extremely grave, from the amount of shock which they involve.

One of the three cases before referred to as treated in my wards at the Episcopal Hospital, in 1882, was that of a laborer, aged 50, upon whom a bank of earth had caved in. The os innominatum on either side had been broken, as above described, close to the sacro-iliac junction, as well as through the os pubis; there were profound shock, retention of urine for several days, and subsequent peritonitis. The man complained of severe pain in the right leg from the hip to the toe; but this gradually subsided along with his other symptoms. As he recovered, the diagnosis above given could not of course be verified beyond question by an autopsy; but the mobility of the fragments, the crepitus, and the long-continued tenderness upon pressure at the points indicated, seemed to warrant my statement of the case.

Another was that of a young man, aged 16, who had fallen about sixteen feet. Pressure on his pelvis from side to side, or over the pubis, caused him great pain, as did also a slight blow on the knee if the thigh was flexed. He suffered less from shock than the patient first mentioned, but had retention of urine for four days. He also recovered.

The *symptoms* of fracture of the pelvis need scarcely be dwelt upon at length. There is always more or less pain, sometimes very severe; it is apt to be greatly aggravated by any attempt at moving in bed. When the sacrum is fractured, the act of defecation is productive of great pain; and urination is similarly interfered with when the pubis has given way. In either case the patient's suffering is increased by coughing or sneezing. Crepitus can usually be felt if pressure be so applied as to cause grating of the fragments upon one another, but it is often by no means distinct. Ecchymosis may or may not be present, as sometimes the fracture affects portions of the bone very deeply situated, and the vessels torn may be at the inner surface. Often the fragments are scarcely at all displaced, and hence no deformity is caused.

It may readily be perceived, therefore, that the *diagnosis* of injuries of this kind may present a good deal of obscurity; and even when the fact of fracture is clearly to be made out, it may be a matter of much difficulty to determine the exact line of separation, especially in stout or fat persons. Examination by the rectum, and in females by the vagina, may enable the surgeon to arrive at greater certainty in this respect. But even the most careful and thorough exploration may fail to ascertain the full extent of the injury. Malgaigne quotes from Lyon a case in which "seven or eight fractures were discovered by dissection, although no crepitation had been perceptible during life, from any movement whatever of the pelvis." I myself know of an instance in which a fracture of the horizontal ramus of the pubis on each side, of the ascending ramus of the ischium on each side, and of the sacrum vertically, with much comminution of its lower extremity and partial separation of the right sacro-iliac symphysis, entirely escaped detection during life. The urethra was ruptured across, and this lesion caused the patient's death a day or two after the accident.

The gravity of fractures of the pelvis is due to the *complications* apt to attend them, rather than to the injury inflicted on the bone. Several cases have been mentioned in which death was the result of rupture of the bladder or urethra. It is not always easy to explain how the bladder is involved, as in some instances the fracture of the pubis is so far from the median line that the fragments can scarcely be supposed to have lacerated it, unless greatly distended, and still more difficult is it to understand in what way the urethra is torn across. Yet very possibly the fracturing force may greatly displace the fragments, which subsequently are restored to their natural position, or nearly so, by the elasticity of the bony structure; or the urethra may be subjected to violent stress between a foreign body below and the pubic arch above—a supposition rendered more likely by the contused and bruised condition of the tissues of the perineum in some of these cases.

Swan[1] relates several interesting cases of fracture of the pelvis, in one of which two inches of the urethra were found at the autopsy to have been torn away. The patient had fallen from a horse, breaking the right pubis through its body and ramus, and separating it at the symphysis. In another case, the patient having been run over by a loaded wagon, the fracture involved the arch of the pubis, several other portions of the ischium and pubis, the right acetabulum, and the right sacro-iliac symphysis. The bladder had a large rent in its anterior part, and the urethra was torn completely through.

Earle[2] records a very curious case, in which, by a fall from a carriage, "the symphysis pubis was separated to the extent of three inches, and the sacro-iliac symphysis on the left side was nearly separated and gaped to the extent of more than an inch. The prostate gland had been torn away from the bladder, leaving a large aperture communicating directly with the cavity of that viscus. The urethra still retained its connection with the ligament on the right side of the pubis, and the prostate gland hung loose in a cavity filled with coagulum. An extensive laceration communicated with the rectum."

Fragments of the fractured pubis have been known to make their way into the bladder. Tillaux[3] saw such a case, and quotes one from Lenoir, in which the bit of bone became the nucleus of a stone. He mentions also that Nélaton once extracted, through the vagina, a fragment which had wounded the bladder. By mere pressure, a displaced fragment may obstruct the passage of a catheter.

The great vessels are not often wounded in cases of fracture of the pelvis, although it would seem as if they readily might be. Earle[4] reports a case, in which, by a fall from a third story window, the left os innominatum was separated at the symphysis pubis and sacro-iliac junction, and "was forced upward to a considerable extent. The common iliac vein on that side had been torn through, and the pelvis was filled with blood." The patient, who had sustained other injuries also, died an hour after the accident. Lucas[1] records three cases, in one of which the right internal iliac vein was wounded, while in another the right external iliac artery was divided, and in the third the left external iliac vein was lacerated.

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[1] Med.-Chir. Trans., vol. xii.

[2] Ibid., vol. xix. p. 257.

[3] Op. cit., p. 830.

[4] Loc. cit., vol. xix. p. 262.

Lente[2] has reported a case in which the small intestine was wounded by a sharp fragment of the ilium.[3]

Another danger which occasionally attends these injuries, is that of extensive suppuration. Of this an instance has been mentioned in a preceding page, and others are upon record.

With regard to the *treatment* of fractures of the pelvis, there is not very much to be said, although the subject is one of great practical importance. Absolute rest in bed is generally a necessity clearly perceived by the patient; and his comfort is often promoted by a broad bandage firmly applied around the pelvis, a thick layer of raw cotton being placed next the skin. When there is a tendency to displacement inward of a fragment, as for instance of the iliac crest, the pressure of the bandage may do harm, and it should either be more loosely fastened, or cut away at this part, or even dispensed with altogether.

Shock, if it be present, as it is apt to be in the early stage of the case, should be combated by stimulants—alcohol, carbonate of ammonium, hypodermic injections of ether, and external heat.

If there be any difficulty in urination, the bladder should be carefully emptied by means of the catheter, and, if the urine thus drawn off be bloody, we may suspect a wound of the bladder or urethra. When the instrument cannot be readily introduced, if the patient have not previously been the subject of stricture, injury to the urethra is probably present, and extravasation of urine must be looked for. Upon the first evidence of this complication, free incisions should be made in the perineum.

Wounds of the large vessels are apt to be fatal from internal hemorrhage before there is any clear indication of the nature of the trouble; but, if this could be made out, the obvious course would be to cut down at the usual point, and apply a ligature.

In case of abscess, incisions should be made at such points as to allow of the readiest escape of pus, and the use of drainage-tubes may be of great advantage.

The comfort of the patient is often greatly promoted by the use of a fracture-bed, as the unavoidable disturbance caused by the insertion of a bed-pan is apt to produce pain. Should the treatment be prolonged, the occurrence of bed-sores must be carefully guarded against, although this may be a matter of much difficulty; a water-bed, or air-cushions, may, however, be used with hope of success.

In the cases of "double vertical fracture," before alluded to, it may be necessary to prevent the riding up of the acetabular fragment by applying extension to the foot; and this is to be done by the weight and pulley, to be hereafter described in connection with the treatment of fractures of the femur.

Mention has been made of the influence of muscular action in the production of fractures of the pelvic bones; and if this can be ascertained as a cause of displacement of the fragments, the necessity of obviating it by position will be evident. Flexion of the thighs on the trunk, as well as of the body forward, will be indicated in any such case.

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[1] Lancet, March 9, 1878.

[2] New York Journal of Medicine, January, 1851.

[3] The reader will find some interesting and instructive cases recorded by Lidell, in a paper on "Ruptures of Pelvic and Abdominal Viscera," in the Am. Journal of the Medical Sciences for April, 1867; and may consult with advantage a monograph, published in 1851, by Dr. Stephen Smith, on "Rupture of the Bladder."

A few words may finally be said as to the *prognosis* in fractures of the pelvis. In simple, uncomplicated cases, there may be no grave symptoms from first to last, and entire recovery may take place. When the bladder or urethra has sustained injury, the risk is greatly increased; and the more so the nearer the lesion is to the cavity of the peritoneum. Complete rupture of the urethra has always, as far as I know, proved fatal. Peritonitis constitutes a very serious complication, but, as in one of my cases above mentioned, may yield to treatment. The other concomitant injuries referred to have always hitherto resulted in death.

In non-fatal cases there has sometimes been permanent lameness, but not very great, nor involving serious disability.

Occasionally, when recovery takes place from fracture of the pelvis, unpleasant after-effects manifest themselves. Thus, in the Pennsylvania Hospital Museum, there is a specimen,[1] taken from a man who had been crushed by a moving car, and who was discharged cured, to be readmitted eighteen months afterward; he was then "suffering from severe sciatic pain, but was able to walk with canes, sitting down, however, only with difficulty. An examination rendered it probable that there was a large amount of callus pressing upon the sciatic nerve, with, perhaps, a fracture of the femur. An operation was performed for removing the head of the femur. Subsequent to the operation, suppurative fever or pyæmia supervened, and death followed on the ninth day." The specimen shows "that the pelvis had sustained a fracture, separating the pubic portion of the bone from the ilium, passing from about the sciatic notch posteriorly to the acetabulum. This is firmly united, but along the line of the fracture, extending forward into the acetabulum, and posteriorly covering more than half the sciatic nerve, are abundant, firm, but porous exostoses. From the spine of the ischium is a hook-like projection, partially surrounding the track of the sciatic nerve. At the junction of the ilium and the ramus of the pubis is a groove measuring nearly an inch in depth, which carried the tendons of the iliacus and psoas muscles. The head of the femur cannot be replaced in its socket, and, at the time of the operation, was found resting in the sciatic region."

Fractures of the Clavicle.

The clavicle, by its articulation with the sternum, affords the upper extremity its only fixed connection with the skeleton of the trunk. Its outer end has a seemingly large, but really quite limited range of motion, and is fastened to the scapula, not only by the small acromio-clavicular joint, but by the wide and strong coraco-clavicular ligament.

At its sternal end this bone is thickest; thence to near the middle it is rounded; here it is flattened below, and turns upward; toward the outer end it becomes very broad and flat, curving forward. The degree of curve varies in different bones, as does also the irregularity of shape just noted, and the size and thickness of the whole bone. Besides the double curve, there is a more or less marked double twist in the clavicle.

As to its muscular attachments, this bone is mainly, indeed almost wholly, an intermediate bone; being placed between the clavicular portion of the sterno-cleido-mastoid and the costo-clavicular ligament, the latter being really the tendon of origin of the muscle; while most of the remainder of its length is simply interposed between the trapezius and deltoid. The connection of the pectoralis major with it is only accessory. The only muscle which acts directly upon the clavicle itself is the subclavius, and the function of this is rather to limit the mobility of the clavicle, than to impress motion upon it.

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[1] No. 1116^{15}, Catalogue (Supplement), p. 22.

Fractures of the clavicle are among those of most frequent occurrence. They are met with at all ages, even in intra-uterine life. In children they are very common; out of 316 cases of fracture treated at the Children's Hospital in Philadelphia, in seven years, the clavicle was affected in 94, or nearly 30 per cent. Between the ages of 15 and 65, according to Malgaigne, the fractures of this bone form about one-quarter of the whole number; and only one-fourth of the patients are females. At a more advanced age, however, he noted that eleven out of eighteen cases were those of women.

By most authors, fractures of the clavicle are divided into those of the inner, middle, and outer thirds of the bone. This, although a convenient arrangement, is not strictly accurate, as some oblique fractures, which occupy the outer portion of the inner third, in part, traverse both this and the middle third. I prefer to speak of fractures of the *body* of the bone, of those near the *sternal* end, and of those near the *acromial* extremity. Fractures of the body of the bone, which may concern the middle third only, or may encroach also upon the inner or more rarely upon the outer third, are by far the most numerous. They are very generally oblique, although occasionally nearly or even quite transverse.

Compound fractures of the clavicle are almost never met with, unless they become so secondarily by a sharp fragment penetrating the skin, which happens extremely seldom; and they are not often comminuted, at least to such a degree as to influence the result. *Incomplete fractures* of this bone have, however, been repeatedly observed, and not a few instances in which, the periosteum being untorn, the fragments have remained in place. Several such, occurring in young subjects, have been recorded by Blandin[1] and Robert,[2] and a number are quoted by Malgaigne from different authors. Hamilton mentions several seen by himself in adults; one of his patients, a woman, was eighty years old. A number of such cases are on record, in which the fact of fracture has been unrecognized until after the occurrence of union.

Fractures of the clavicle may be caused by *direct force*, as by a blow, by the recoil of a gun, by the fall of a heavy body upon the shoulder; by *indirect force*, as by a fall on the point of the shoulder, or upon the hand; or by *muscular action*, as by the effort to pull down the brace of a carriage-top,[3] or in striking a blow with a whip.[4]

In inquiring into the mechanism of the production of fracture under either of these conditions, it must not be forgotten that the inner or sternal end of the bone is firmly fixed, and that, as before stated, the range of motion of the acromial end is but limited. There is another anatomical fact, pointed out by me many years since,[5] which I believe to be of much importance in connection with this subject. It is the close relation which often subsists between the clavicle and the first rib; by reason of which, when the outer end of the former bone is forced downward, the bone itself becomes a lever of the first order, the rib being the fulcrum. In some persons the upper part of the thorax comes much more nearly to a point than in others, the arch of the first rib being smaller, and the bone itself more delicate. Again, in some persons the clavicle is much straighter, and stands out more directly from the sternum than in others. I think that these two conditions usually correspond. When the first rib forms a wide and strong arch, and the collar-bone runs somewhat backward as well as closer to the rib, the two bones may even be almost in contact as far nearly as to the middle of the clavicle. In such a case, a blow, the recoil of a gun, or any force driving or dragging the outer portion of this bone downward, or downward and backward, would act on the bone as a lever, and tend to break it at any point where it might be weakest. The rib, being a strongly stayed arch, pressed upon at its convexity, would not give way; while the clavicle would be at a disadvantage, being subjected to a force at its concavity, tending to increase its curvature. I think that this was clearly the mechanism of the following case, mentioned by Malgaigne: "I have seen an incomplete fracture of the clavicle resulting from the pressure of a burden which slipped from the shoulder down on the arm, and thus, pulling downward on the outer end of the bone, bent and broke it at about the middle."

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[1] Am. Journ. of the Med. Sciences, April, 1843; from Journal de Méd. et de Chir. Pratiques, Juillet, 1842.

[2] Ibid., Jan. 1859; from L'Union Médicale.

[3] Hamilton, op. cit., p. 193.

[4] Parker, New York Journal of Medicine, July, 1852.

[5] New York Medical Journal, Oct. 1866.

Very possibly this leverage over the first rib may have something to do with some fractures by indirect violence, as when a man falls forward on his outstretched hand, and the scapula, forced backward by the head of the humerus, carries the acromial end of the clavicle along with it.

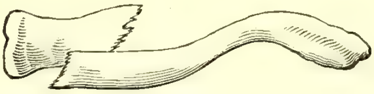
There are cases in which it would seem that the clavicle is broken by the forcing upward of its acromial end; and these can only be explained by the firmness of its ligamentous attachment to the sternum, and the unyielding character of the rhomboid or costo-clavicular ligament. Perhaps, however, more accurate information as to the circumstances would set this theory aside. Often the surgeon has to be content with very vague statements on the part of the patient or his friends, and caution is needful in drawing conclusions from premises which may be wholly or in part incorrect.

When the clavicle gives way to a force acting at its outer extremity, as in the case of a fall on the point of the shoulder, it may be easily seen that the mechanism is simply the exaggeration of the normal curves, carried so far as to overcome the resistance of the bony structure. And the more suddenly the stress comes, the more likely is the bone to be broken. The point at which the fracture shall occur is determined by the exact direction of the force, and perhaps in some degree by the action of the muscles at the moment. But in the very large majority of cases the line of fracture runs obliquely through the body of the bone, from within outward and from before backward. The relation of the obliquity to the upper and lower surfaces, I do not know; it is probably not a constant one.

Symptoms of Fractured Clavicle.—Upon the occurrence of fracture of the clavicle, if the periosteum yields, there is generally marked *displacement.* And this may be either a mere prominence of the inner fragment, or a positive projection, the outer fragment being carried behind the inner so as to make the latter start forward. This is the almost universal rule; but cases have been observed in which the outer fragment has been in front of the inner. The annexed cut (Fig. 600) represents the clavicle of a patient in my wards at the Episcopal Hospital in 1882, in whom the outer fragment was directly below the inner. The man was a German teamster, and said he had fallen down, striking his shoulder; he could give no details of the accident, and at the time when I saw him there was no bruise or other indication of the exact point of impact. The complete reduction of the fracture was impossible, but a good recovery ensued, with some superabundance of callus. I cannot offer any explanation of these exceptions; but it will be seen that in my case the fracture involved the sternal third of the bone.

Sometimes, when the cause of the fracture has been direct violence, it is sufficiently obvious that the outer fragment has been driven back from the inner. But there must be a further reason for the very general existence of this displacement, and I believe it is to be found in the changed position of the scapula. Upon the loss of the stay afforded by the unbroken clavicle, the serratus magnus and pectoralis minor muscles pull the scapula forward and inward, while perhaps the rhomboidei muscles draw up its lower angle. The acromion is thus brought nearer to the median line, and tilted downward; the effect of which is to push the distal fragment of the broken clavicle inward, and to depress its outer end. This seems to me to afford an ample explanation of the very constant occurrence of this form of displacement. Very possibly the fibres of the subclavius may also draw upon the outer fragment, and aid in the production of the deformity. The forcing of the outer fragment behind the inner will tilt the latter upward and forward; and my belief is that to this, and not to the action of the clavicular portion of the sterno-cleido-mastoid, is due the projection of the inner fragment so commonly present. The action of the last-named muscle, indeed, is from below upward (the Germans call it "Kopf-nicker," that is, head-nodder), and through the rhomboid or costo-clavicular ligament it gets an origin from the first rib. This ligament would of itself prevent the drawing up of the inner fragment, unless, as sometimes happens, it should be itself ruptured.

Fig. 600.



Fracture of clavicle with downward displacement of outer fragment.

By all authors we are told that the shoulder falls forward, inward, and downward, and that this displacement is due to the weight of the shoulder and of the upper extremity. It is true that the shoulder does thus change its position; yet the muscles which support it are not impaired, and the mere lifting of the weight does not remedy the deformity. When the scapula itself is drawn back into position, and only then, does the outer fragment of the clavicle resume its normal relation to the inner.

The explanation now given of the cause of deformity in fracture of the clavicle finds strong confirmation, I think, in the condition observed when the bone is broken near the acromial extremity. Here the short outer fragment is pushed round forward and inward, so as to form almost or quite a right angle with the inner, the broken end of the former even coming in contact with the anterior wall of the latter. Many museum specimens exist in proof of this statement, and two such are in the Mütter collection in this city. Malgaigne mentions two cases of fracture very near the acromial end, in which union had taken place. In each of them, "the shoulder was depressed, and carried forward and inward; . . . and to this inclination of the shoulder there corresponded posteriorly a notable prominence of the inferior angle and posterior edge of the scapula." Both the patients had perfect motion of the arm, except backward. Here it seems to me quite plain that the change of shape is to be accounted for as follows: partly by the action of the clavicular part of the trapezius, drawing up both fragments, and favored in so doing by its attachment to the natural convexity of the bone; partly by the tilting upward and backward of the lower angle of the scapula by the rhomboideus major muscle, aided by the weight of the arm dragging on the upper and outer angle of the bone, and through the acromion on the outer end of the clavicle; but chiefly by the serratus magnus and pectoralis minor carrying the whole scapula forward and inward around the side of the thorax, and thus bringing the outer fragment into exactly the position described with regard to the inner.

A case mentioned by Malgaigne so strongly illustrates the theory now stated, that I venture to quote it at length:—

> The patient had sustained a fracture of both clavicles by a fall from a window fifteen feet high. Non-union had occurred in both bones, and the impairment of function was such that he could not resume his former occupation as a tinsmith, but became a tailor.
>
> "Both clavicles had been broken at the middle; the two inner fragments were nearly horizontal, and very distinct beneath the skin; the outer fragments had also a nearly horizontal direction, but were buried behind and below the others, to which they seemed to have no adhesions of any kind. The overlapping was considerable.
>
> "When he stood up the two shoulders seemed lower, as well as carried further forward and inward, than in a healthy person. The one on the right side was higher, and at the same time closer to the sternum, than the other. Posteriorly the scapulæ were separated from the spinal column by three or four inches, and inclined forward and outward; and, on the whole, the thorax seemed contracted at its upper part.
>
> "He could draw the shoulders back a little, but not enough to overcome their apparent prominence anteriorly. On the other hand, he could draw them together forward so that they seemed like wings covering the chest, and leaving between them, in front of the sternum, only three inches of space. In this movement the scapulæ *fitted to the sides of the trunk*, and the back seemed rounded from one side to the other, almost like that of a skeleton deprived of its upper extremities. The shoulders could be raised also at will, but not to any extent, from want of muscular power."

Professor Gordon, of Belfast, has expressed[1] views in regard to the displacement in fractures of the clavicle, exactly the same as my own. As he has not referred to my paper, I presume that he is not aware of its existence. Though these views have not as yet received the general assent of surgical writers, my belief is that they are correct, and that they will ultimately obtain acceptance.

Prof. Moore, of Rochester, N. Y.,[2] regards the relaxation of the clavicular fibres of the pectoralis major muscle, and the consequently unopposed action of the sterno-cleido-mastoid, as the great cause of the displacement; but it does not seem to me that this view is tenable.

I say nothing of rotary displacement, because nothing of the kind has ever occurred in the cases under my notice, and I do not think it exists.

Pain is an almost constant symptom of fracture of the clavicle. When the line of separation is oblique, as in most cases, this is obviously due partly to the pressure of the ends of the fragments, especially of the inner, against the skin. According to Tillaux, it is the filaments of the supra-clavicular nerve, in the platysma myoides muscle, which are thus irritated; but the fact that there are often pain and numbness down the arm, and even in the fingers, affords proof that the large trunks of the brachial plexus are also interfered with. In order to obtain relief, patients are very apt to assume a position which, by some authors, has been considered almost a diagnostic sign; they support the arm of the injured side by placing the other hand under the forearm, and incline the head toward the affected shoulder.

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[1] Dublin Quarterly Journ. of Med. Science, Nov. 1859. Also in a Treatise on Fractures of the Lower End of the Radius, on Fractures of the Clavicle, and on the Reduction of the Recent Inward Dislocations of the Shoulder-joint. London, 1875.

[2] Trans. of Med. Soc. of State of N. Y., 1870, p. 107.

Swelling is very apt to occur, especially in fractures caused by direct violence, and attended with much bruising of the soft parts; but it is not often so marked as in some other regions, nor does it generally mask the condition of the bone so completely, by reason of the small amount of subcutaneous areolar tissue existing here.

Ecchymosis may or may not be present, according to the character of the fracture and the amount of injury to the small veins of the skin. It is very rare to have the deep staining of the surface, coming on slowly and very gradually subsiding, which is often met with in the case of the larger bones.

Crepitus is very generally to be felt. It suffices to gently press the point of the shoulder forward, the fingers of the surgeon's other hand being lightly laid over the bone, to develop a sufficient sound. Sometimes, indeed, this is the only symptom present. M. Guerin[1] has reported the case of a man aged 60, whose clavicle was broken by a fall of earth. During life the only positive symptom of the injury was slight crepitus. After the patient's death (from pneumonia) the fragments could be made to project by means of the finger passed behind the bone.

Along with the crepitus, and shown by the same manœuvre, there is often perceptible an abnormal *mobility* at the seat of fracture. The degree of this will be dependent upon the completeness, not only of the fracture, but of the tearing of the periosteum, as well as upon the direction of the line of breakage, and often upon the amount of serration of the fragments. But whether slight or otherwise, it is an unmistakable proof of the character of the lesion.

Fractures of the *sternal portion* of the clavicle are much less frequent than those of the acromial extremity, and very rare indeed as compared with those of the body of the bone. They have attracted but little notice, an article by Delens[2] being the fullest source of information in regard to them up to the present time. This author states that while they have been observed as the result of both direct and indirect violence, muscular action is by far their most frequent cause. One instance of the latter kind has been reported by Heath:—[3]

A boy of fourteen, "whilst raising his arm violently to bowl at cricket, felt something give way at his collar-bone. The inner end of the clavicle was found to be unduly prominent, and presented a sharp edge beneath the skin, quite unlike the smooth end of a bone covered with articular cartilage. The supra-sternal notch was quite distinct, and equally defined on both sides, and a thin lamella could be felt on the right side, intervening between it and the gap caused by the starting forward of the inner end of the clavicle. The treatment consisted in laying the patient down, when the bone at once dipped into place, and was retained by a plaster-of-Paris bandage." This cannot have been, as was suggested, a separation of the epiphysis, since no such formation takes place, according to anatomists, before the twentieth year; and perhaps it might more correctly be placed under the head of sprain-fracture.

Of fractures by indirect violence, the clearest instance is that recorded by Willis:—[4]

A man, aged 54, slipped off a hay-rick, falling on his outstretched right hand, and striking his right shoulder. On examination, there was discovered a simple fracture of the right clavicle within a quarter of an inch of the sternal head of the bone. The direction of the fracture was obliquely downward and outward. The outer fragment was tilted up, partly by the direct action of some of the fibres of the sterno-cleido-mastoid, partly by the weight of the arm dragging the acromial end downward; it was very sharp, and threatened to pierce the skin. Much difficulty was experienced in coaptation of the ends, which could only be fully effected by strongly raising the arm—

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[1] Gaz. Hebdom., 20 Sept. 1867.

[2] Arch. Gén. de Médecine, Mai, 1873.

[3] Brit. Med. Journal, Nov. 18, 1882.

[4] Lancet, Dec. 2, 1882.

a position which the patient either could not or would not long tolerate. A sling, and a compress over the clavicle, were employed; and a year subsequently, the sharp fragment had been greatly rounded, and fibrous union had occurred.

Willis thinks, and with reason, that in this case the rhomboid or costo-clavicular ligament was ruptured.

A case has been published[1] (without the reporter's name) as occurring at the Mount Sinai Hospital, in New York, in which the clavicle was broken about an inch from the sternum. The cause of the injury is not mentioned; but it is stated that the inner fragment was vertical, and the other "down upon the chest." The deformity caused no inconvenience, and was not remedied. The reporter ascribes it to the action of the sterno-cleido-mastoid. I quote this report, notwithstanding its vagueness, because it seems to me to be illustrative of the proper division of these injuries; the lesion was really, although near the inner end, simply a fracture of the body of the bone, in which the displacement was of the ordinary kind, and due to the same causes as before mentioned; but was exaggerated by the shortness of the inner fragment. Possibly, the rhomboid ligament being torn, the muscle may have contributed to the elevation of the inner fragment, but I do not think it alone could have produced it.

The view I wish to maintain is, that the mechanism of fractures of the inner third of the clavicle is the same as that of fractures of the middle third, and that the displacement occurs in the same way; and hence I would simply class them with fractures of the body of the bone.

Fractures involving the sternal end of the clavicle are, however, distinguished by certain features, as may be readily seen in the instances before quoted from Heath and Willis. Lonsdale[2] mentions the case of a boy, aged 3, who fell and struck his shoulder against the edge of a step, fracturing the clavicle about half an inch from the sternum; he says that "the crepitus of fracture could be distinctly felt, and the end of the bone moved from its natural position."

Fractures of the *acromial* extremity of the clavicle embrace all those which affect the bone anywhere between the acromio-clavicular joint and the inner edge of the coraco-clavicular ligament. They may be caused by direct or indirect violence; it is difficult to see how they could result from muscular action, and I know of no record of any such case. Indeed, the clinical history of these lesions is very meagre; but specimens in which union has taken place are by no means rare. Ossification of the coraco-clavicular ligament, more or less complete, has been noted in some of the cases.

It has been already stated, in speaking of the mechanism of fractures of the body of the clavicle, that the condition observed when the outer third of the bone is broken, is dependent upon the dragging forward and inward of the scapula, by the action of the serratus magnus and pectoralis minor muscles.

Occasionally the clavicle is broken at more than one point. Malgaigne mentions and figures a remarkable specimen, without history, in which one fracture is near the sternal end and the other near the acromial. He speaks of the case of a little girl who had a double fracture, the middle fragment, less than an inch in length, being tilted up in a vertical position between the others, so that it could not be reduced. Conner[3] says that he obtained at an autopsy, at the Charity Hospital at New Orleans, "a right clavicle which had been broken in two places, the union being ligamentous at both."

Simultaneous fracture of *both clavicles* has sometimes been met with. One case recorded by Malgaigne has already been quoted, in illustration of the mechanism of the displacement. Gurlt gives fifteen, all produced by very great violence. Besides these, Lane,[1] Burr,[2] and Wight[3] have published cases of the kind. Wight's patient had good union in the bone of the left side, but only ligamentous in the right; yet he could work as well as ever. These cases have a special interest, to be further referred to, in view of the difficulties presented in their treatment.

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[1] New York Med. Journal, Jan. 1877.

[2] Op. cit., p. 206.

[3] Holmes's System of Surgery, Am. ed., vol. i. p. 848.

Diagnosis.—The diagnosis of fracture of the clavicle is for the most part easy; the attitude of the patient, the loss of power in the arm, the seat of pain, the projection of the fragment or fragments which can often be both seen and felt, the crepitus, and the abnormal mobility—all these signs, with the history of a fall on the hand, or on the point of the shoulder, or of violence applied to the part, or of stress put upon the bone by sudden muscular exertion, will generally lead even a non-professional person to a true construction of the case.

When, as in transverse fractures, with little or no displacement, deformity is wanting, pain is slight, and crepitus is hardly to be perceived, the existence of tenderness at a special point, developed either by direct pressure or by a push or tap on the acromial end of the bone, should suffice to indicate the nature of the injury.

The caution given in regard to some other cases, as to undue zeal in the eliciting of symptoms, may be emphasized here; as there are instances on record in which, in able hands, incomplete fractures have been made complete, of course increasing the risk of deformity. Should there be any doubt, it would be right to treat the case as one of fracture; keeping the arm and shoulder at as perfect rest as possible, and watching for the occurrence of more positive symptoms.

Complications.—Examples of complicated fracture of the clavicle, although not by any means of frequent occurrence, have been often enough recorded to make it surprising that Malgaigne should have known of no such cases.[4] These complications may consist in injuries of the artery, veins, or nerves; of the lungs; or of other bones. They may ensue immediately, or may be among the later phenomena; and they differ greatly in the degree of their gravity, of the suffering which they cause, and of their amenability to treatment.

Evans[5] reports a case in which an aneurism of the *innominate artery* was ascribed to a fracture of the right clavicle sustained by the patient, a sailor, many months before he came under surgical observation. Dupuytren is said by Delens[6] to have given, in a clinical lecture in 1831, several cases of aneurism from a like cause.

Injury of the *veins* is somewhat more frequent. Holmes[7] says, "I have once seen death result from this injury in consequence of the fragment having lacerated the internal jugular vein." Hulke and Flower[8] mention a specimen (perhaps from the same case) of like injury. They also refer to the case of Sir Robert Peel,[9] in which there was "a comminuted fracture of the left clavicle, below which a swelling as large as the hand could cover, and which pulsated synchronously with the contractions of the auricles of the heart, formed." It seemed probable, from the pain, that some cords of the axillary plexus had also been injured.

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[1] Lancet, July, 1876.

[2] Medical Record, May 6, 1882.

[3] Med. Gazette (New York), 1882.

[4] Op. cit., p. 471; translation, p. 382.

[5] Transactions of Pathological Society of London, vol. xvii. 1866.

[6] Arch. Gén. de Médecine, Août, 1881.

[7] Surgical Treatment of the Diseases of Infancy and Childhood, 1st ed., p. 248.

[8] Holmes's System of Surgery, 2d ed., vol. ii. p. 769; Am. ed., vol. i. p. 848.

[9] Lancet, July 6, 1850 (editorial article).

Boone[1] reports a case in which a fragment from a comminuted fracture of the clavicle produced somewhat serious symptoms by pressure upon the subclavian vein and adjacent nerves. Erichsen[2] gives a similar case, in which, however, death ensued from gangrene of the arm. Maunoury[3] records an instance of fracture of the clavicle with rupture of the subclavian vein; great swelling having occurred, an incision was made, and death immediately resulted from hemorrhage and entrance of air into the vein.

Of injuries of the *nerves* a good many instances are recorded, only a few of which need be quoted here. Gibson[4] saw a young man, who had sustained a comminuted fracture of the clavicle by direct violence; "the fragments had been driven behind and beneath the level of the first rib, and so compressed the plexus of nerves as to wedge them into each other, and by the subsequent inflammation to blend them inseparably together. Complete paralysis and atrophy of the whole arm ensued." The patient desired to obtain relief by operation, but Gibson deemed the chance of success too small, and declined to attempt it. Surgeons of the present day would probably have taken a more hopeful view, and cases will be hereafter mentioned in which operative interference has been attended with good results.

Chalot[5] reports that "in the case of a man of 35, disturbances of innervation showed themselves in the right arm as a result of fracture of the clavicle. Beginning with a sensation of deadness, formication, and pricking, particularly in the palm of the hand, the affection went on to extreme anæsthesia. Very slight irritation of the finger-tips, or the hollow of the hand, or somewhat greater movements of the flexor surface of the forearm, brought on nausea, gagging, and vomiting, with occasional severe diaphragmatic cramp and thoracic oppression (Beklemmung). The patient became first pale, then red; a cold sweat covered the forehead on the affected side. Irrigation with cold water caused the symptoms to appear to a more marked degree, while warm water made them milder. The extremity became smaller, colder than the healthy side, the skin everywhere dry except in the hollow of the hand, there wet with perspiration. The muscles reacted weakly. Pressure upon the branches of the nerves brought on swimming in the head and faintness. Pressure upon the callus at the point of fracture of the clavicle, which had united with considerable deformity, was quite painful, and gave rise to diaphragmatic cramp. Pressure upon the nerves of the face, throat, and nape of the neck, on the affected side, caused similar symptoms." The further history of the case is not given.

Gross[6] mentions a case of partial paralysis of the upper extremity, with atrophy and permanent contraction of some of the muscles, in a boy of fifteen, the clavicle having been broken by the recoil of a shot-gun four months and a half previously.

Delens[7] records a case in which the superabundant callus of a fractured clavicle (two ribs also having been broken) exerted such pressure on the subclavian vessels and nerves as to impair the nutrition and muscular power of the limb. Relief was afforded by a subperiosteal resection. Two other instances, in which resection of the fragments was practised, one observed by Gosselin and the other by Perier, are referred to in this article.

Perhaps it may be remarked here that care is to be taken not to confound nerve-lesions due to the original injury with those which may be brought on by the pressure of apparatus, as pointed out especially by Hamilton, and to be further discussed in connection with treatment.

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[1] Medical Record, November 15, 1873.

[2] British Medical Journal, June 7, 1873.

[3] Progrès Médical, 1882, tome x. p. 302. Reference is here made also to a monograph by Champomier, "Contribution à l'étude des lésions des troncs veineux de la base du cou dans les fractures de la clavicule." Paris, 1882.

[4] Op. cit., vol. i. p. 254.

[5] Philadelphia Medical Times, March 27, 1880, from Centralbl. für Chirurgie.

[6] Op. cit., vol. i. p. 946.

[7] Arch. Gén. de Méd., Août, 1881.

Wound of the *lung* is said to have been several times noticed in connection with fracture of the clavicle, but I am not aware that it has ever been verified by an autopsy except once. Hammick[1] speaks of a man who had had a fracture of the clavicle three days before he came under observation; he died of pneumonia, and on dissection it was found that the fractured portion was so depressed as to have wounded the pleura and torn the lung. Gibier[2] reports a case in which the acromial fragment wounded the lung, and produced emphysema; the patient recovered, but with non-union of the fracture. Mercier[3] gives a similar case, and refers to several others.

The uncertainty in all these cases in which recovery takes place, is not with regard to the wound of the lung, which is sufficiently established by the occurrence of emphysema, and occasionally by hæmoptysis, but as to the mode of its production—whether there is not a fracture of a rib as well as of the clavicle. It is not, however, a matter of serious importance; the relation of the apex of the lung to the clavicle is, in most persons, such that a wound of the former might readily occur by a fragment of the broken bone.

The complication of fracture of the clavicle with that of *other bones* sometimes presents itself. It is chiefly of interest in connection with treatment, and will be considered under that head.

Prognosis.—As a general rule, the prognosis in fracture of the clavicle is favorable. Union takes place, in children especially, with great rapidity. Berry[4] states that in six cases, the ages ranging between five months and five years, the clavicle was found united firmly in from nine to fourteen days; the longest time being noted in the youngest child. Bouchut[5] says that Cloquet saw, at the Hospice de l'Humanité at Rouen, a broken clavicle in a girl aged six, consolidated on the ninth day. In adults, consolidation takes place more slowly, averaging perhaps twenty-five or twenty-eight days.

Non-union is sometimes met with, as has already appeared in the preceding pages; but it is not by any means as common as in some of the other bones. A case is mentioned[6] of "a girl aged nine, who had broken her clavicle a month before, and had had no treatment; the sternal fragment projected upward at an angle of 45°, its sharp extremity forming a visible prominence in the side of the neck. The other fragment was fully an inch below this, and connected with it by what appeared to be a band of fibrous tissue, passing nearly vertically between them." Even when the fragments fail to become solidly united, the usefulness of the arm seems to be but little impaired, according to the testimony of Hamilton and others.

As to the avoidance of deformity after fractures of the clavicle, it must be confessed that perfect success is very rarely obtained. In almost every instance there remains a perceptible projection of the inner fragment, even after time enough has elapsed for the disappearance of all swelling due to callus; and in some cases the deformity thus produced is very marked. But as a general thing the complete restoration of the usefulness of the limb is not interfered with, although Hurel[7] assigns the shortening of the bone as the cause of the loss of power sometimes noted. Every experienced surgeon, however, has seen old fractures of this bone united with great overlapping, but with no apparent weakening of the member.

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[1] Op. cit., p. 159.

[2] Bull. de la Soc. Clinique de Paris, 1881.

Thèse de Paris, "Des complications des fractures de la clavicule, et en particulier de la blessure du poumon," 1881.

[4] New England Medical Monthly, March 15, 1883. [5] Op. cit., p. 757.

[6] Holmes's System of Surgery, 2d ed., vol. ii. p. 766; Am. ed., vol. i. p. 846.

[7] Considérations sur les Fractures de la Clavicule. Paris, 1867.

The amount of injury done to the soft parts can scarcely be left out of the account in forming a prognosis, since bruising of the large nerve trunks passing beneath the bone may interfere seriously with the nutrition and functions of the arm and hand, perhaps even permanently. Of this there is obviously most risk in fractures due to direct violence.

Treatment.—The treatment of fractures of the clavicle is a subject upon which a great deal has been written, and a vast amount of study expended. Hamilton justly says, in regard to the varieties of apparatus: "A catalogue of the names only of the men who have, upon this single point, exercised their ingenuity, would be formidable, nor would it present any mean array of talent and of practical skill."

I shall endeavor to set forth the principles involved, and the means devised for carrying them out, as briefly and clearly as possible, referring the reader to other sources for more detailed descriptions of such contrivances as are not now in general use. Cases occasionally do well even without any treatment at all. Newton[1] has recorded one in a soldier, and Porter[2] one in a doctor; in each the result is said to have been "good."

As in the case of other fractures,, the treatment of the broken clavicle consists in its reduction, or the correction of the deformity, and in keeping the fragments in proper position until their union is accomplished. The first of these processes varies greatly in the degree of difficulty attending it in different cases; being sometimes effected with the utmost readiness, while it is occasionally impossible. Oblique fractures, as a general rule, are more easily reduced than transverse; and those attended with but little irregularity of the ends of the fragments, give less trouble than those in which they are deeply serrated. When the displacement is readily overcome, however, it is apt to be as readily reproduced; or, in other words, the difficulty of reduction and that of retention are inversely proportionate.

Some writers, and Malgaigne among them, have described various modes of procedure for the replacement of the fragments; such, for example, as for the surgeon to apply his knee between the patient's shoulders, while with his hands he pulls the shoulders backward. Unless the views I have presented as to the mechanism of the displacement are at fault, manœuvres of this kind are needlessly forcible; and in my own experience I have found that reduction is best effected by grasping the scapula, and bringing it back around the thorax toward the median line. Generally it will be found that as the acromion is thus shifted it carries with it the outer fragment of the clavicle, and that the line of the latter bone is restored.

When the patient is very muscular, or the fragments are strongly interlocked, it may be well for the surgeon to commit the management of the scapula to an assistant, and to employ his own hands in gently moulding and pressing the fragments, which will often yield to this coaxing process, and the bone will thus resume its normal shape. Such a procedure is especially applicable to fractures seated at or close to the sternal end of the bone.

By most authors it has been laid down as the great principle of treatment of fracture of the clavicle that the shoulder must be carried upward, outward, and backward. My only objection to this statement is that it is not quite precise enough; it is the *acromion*, upon the position of which the retention of the fragments must depend. That this is quite a different matter may be readily shown.

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[1] Medical Record, March 4, 1882.

[2] Ibid., April 8, 1882.

Let a pad be put into the axilla, and pushed up so as to carry the shoulder upward and outward, while the elbow is brought strongly forward so as to bear across the pad, and by leverage to carry the shoulder backward; all this can be done with a sound clavicle, and the change in the shape and position of the shoulder *apparently* effected. But, in fact, all that has been done is to put the soft parts on the stretch; the head of the humerus, and this only, has been forced outward and backward, the capsular ligament of the joint and the muscles yielding before it, while the folds of the axilla are pressed upward by the pad.

When, however, the scapula is grasped and drawn around backward, toward the median line, it will be found that the sound clavicle must follow it; and the motion will be checked as soon as the acromial end of the latter bone has reached the limit of its range.

I feel assured that the recognition of this principle and its application to the treatment of these fractures, will lead to the securing of better results than have been hitherto obtained. Indeed, as I shall presently try to show, the apparatus employed in these cases is often capable of effecting only the apparent change above referred to in the shoulder, and does not act upon the broken bone at all.

When a patient with a broken clavicle is laid flat on his back on a firm and even mattress, it will often be found that the deformity disappears simply by reason of the pressure on the posterior border of the scapula; sometimes, however, this must be aided by the hand of the surgeon bearing backward (downward) against the injured shoulder, or pushing the head of the humerus inward (toward the median line). Advantage has been taken of this fact, and, in a number of cases, cures without deformity have been obtained by simply keeping the patients on their backs in bed until union has occurred. The irksomeness of this plan of treatment, and the difficulty of carrying it out, are sufficient objections to it in all but exceptional cases. Women will sometimes undergo it for the sake of avoiding an unsightly lump on the neck; but for the most part patients prefer the application of apparatus with which they can move about, and pursue some at least of the ordinary avocations of life.

Much the same principle has been had in view in all the forms of back-splint, from the *croix de fer* of Heister (or Arnaud) to those of Keckeley[1] and Grewcock.[2] It appears also, but somewhat modified, in the figure-of-8 bandages and other appliances for drawing the shoulders together at the back.

In modern times the tendency has been to depend upon bandages and slings of different forms, with or without axillary pads. Of these, that of Desault, although cumbersome, difficult of application, and apt to become disarranged, long enjoyed a confidence due rather to the prestige of its author's name than to its own merits; it has now been superseded, and its description, which may be found in many works of easy access, need hardly be repeated here.

Mayor[3] proposed a very simple dressing, which may answer a good purpose as a temporary resource, but is scarcely to be relied upon as a permanent mode of treatment. It consists of two triangular pieces of linen; the elbow being carried inward and forward, one triangle is applied over it, its base upward, and corresponding to the level of the lower third of the arm, its point hanging below and in front of the elbow; the two ends are carried round the chest, and meet to be tied or pinned at the sound side. The point of the triangle is now brought up, passed between the arm and the chest, and drawn strongly upward toward the sound shoulder. Now, the middle of the second triangle is sewed to the portion of the first which is behind the back, and its ends are brought up over the shoulders, one to be tied to the point of the first, and the other to come over the broken clavicle and down to the base of the first triangle, to which it is firmly fastened.

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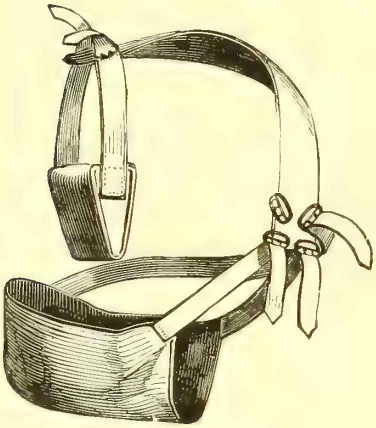
[1] American Journal of the Medical Sciences, Nov. 1834.

[2] British Medical Journal, Nov. 7, 1868.

[3] Nouveau Système de Déligation, etc. Zurich, 1833.

Fox's apparatus, which has been extensively used in the United States since 1828, and is still employed by many surgeons, consists of a padded ring for the sound shoulder, an axillary pad of wedge shape, and a sling for the elbow of the injured side; the pad and sling being furnished with tapes in front and behind for attachment to the ring.

Fig. 601.



Levis's apparatus for fracture of the clavicle.

Levis's apparatus[1] (Fig. 601), is constructed on the same principle, but the padded ring for the sound shoulder is dispensed with, a band over the back of the neck and front of the sound shoulder being substituted for it. To this the elbow-sling is attached by a band across the patient's back, and two across the chest. Dr. Levis uses straps and buckles instead of tapes, and keeps the elbow by the side —not drawn forward.

Professor Moore has proposed[2] a bandage, which he calls "the figure-of-8 of the elbow." He keeps the arm parallel to the axis of the body, with the elbow close to the trunk, and uses "a shawl or piece of cotton cloth, which when folded like a cravat, eight inches in breadth at the centre, should be about two yards long. Placing this at the centre across the palm of the surgeon, he seizes with this hand the elbow of the patient which corresponds with the broken clavicle. The two ends of the bandage hang to the floor. The one falling inward toward the patient is carried upward, in front of the shoulder and over the back, making a spiral movement in front of the shoulder; this is entrusted to an assistant. The outer end is then carried across the forearm, behind the back, over the opposite shoulder, and around the axilla. This meets the other end, which may be carried under the axilla and over the shoulder of the opposite side, thus making the figure-of-8 turn around the sound shoulder. This twist, it will be seen, makes also the figure-of-8 turn around the elbow of the affected side." The forearm is to be supported, with the elbow acutely flexed, by means of a sling. Hale[3] has modified this dressing by the addition of an adjustable back-sling, to be tightened during the day, and loosened at night.

What is known as Sayre's apparatus[4] consists of two broad bands of adhesive plaster; one surrounds the upper part of the arm of the injured side, and thence runs across the back and round the thorax; the second, beginning in front of the sound shoulder, passes over it, and diagonally across the back to the opposite elbow, thence up again, embracing the whole forearm and hand, to be fastened at or near the point of starting. A longitudinal slit in this strip receives the elbow, which is to be drawn well forward and inward.

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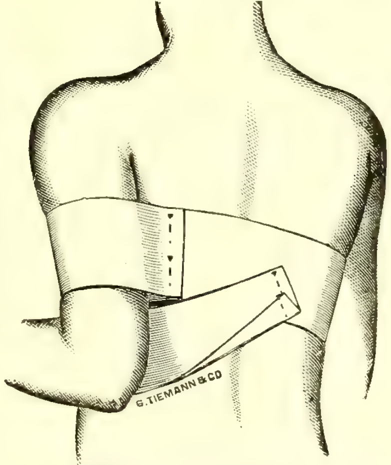
[1] Am. Journal of the Medical Sciences, Jan. 1856.
[2] Transactions of the Medical Society of the State of New York, 1870.
[3] Medical Record, May 27, 1882.
[4] Bellevue and Charity Hospital Reports, 1870.

Satterthwaite[1] has proposed the substitution of the rubber bandage for adhesive plaster, and the use of a horseshoe-shaped dilatable bag, to be filled with water, as an axillary pad. The exact advantages to be derived from this change do not clearly appear, and the risk of excoriation would seem to be increased.

Hamilton describes his own method as follows:—[2]

"The arm hanging perpendicularly beside the body, a sling is placed under the elbow and forearm, and tied over the opposite shoulder. An axillary pad, composed of cotton batting inclosed in a cloth cover, is placed well up in the axilla, and the elbow is then secured firmly to the side of the body with several turns of a roller."

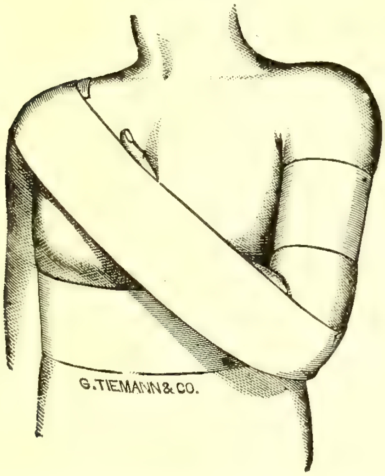
Fig. 602.



Dr. Sayre's dressing for fractured clavicle; application of first strip.

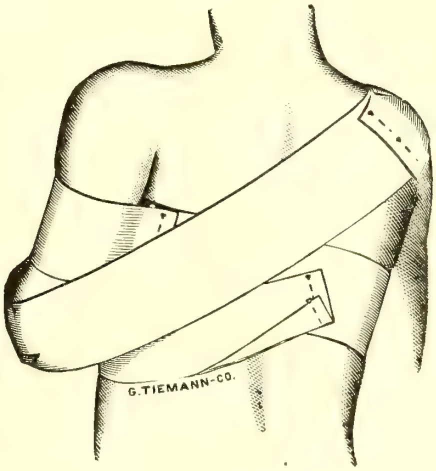
In addition to the somewhat numerous American devices already spoken of, I may merely mention those of Brown,[3] Chisolm,[4] Palmer,[5] and Bradner;[6] all of these have the advantage of simplicity, and it is claimed by their inventors that good results have been obtained by their use.

Fig. 603.



Dr. Sayre's dressing for fractured clavicle completed. Front view.

Fig. 604.



The same. Back view.

Professor Gordon, of Belfast, the agreement of whose views with my own has been before mentioned, describes an apparatus of his own devising, consisting of a breast-plate and arm-splint, connected by means of a rod—the idea being to substitute the broken bone by this rod. Without questioning the theoretical value of this contrivance, or the statements of Professor Gordon as to the results obtained with it by him, I think that its complexity, and the fact that it can only be made by a skilled mechanic, will preclude its adoption, and, to a very great extent, its trial by other surgeons.

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[1] Medical Record, September 27, 1879.

[2] Op. cit., 6th ed., p. 218.

[3] Am. Medical Recorder, Oct. 1821.

[4] Charleston Medical Journal, March, 1858.

[5] Am. Journal of the Med. Sciences, July, 1863.

[6] Medical Record, June 17, 1882.

Professor Byrd, of Baltimore, has published[1] an account of an apparatus successfully used by him, consisting of two padded plates which are applied over the scapulæ; these are connected by a flat steel bar, carrying a lever which arches over the shoulder, and which has at its anterior end another padded plate, to press the shoulder backward. The apparatus is adjustable by screws, and kept in place by straps and buckles.

O'Connor[2] has recently proposed the use of plaster of Paris, somewhat as in the Bavarian splint (see p. 55), so as to make a sort of mould of the shoulder, the fracture being first reduced.

By some surgeons, compresses are applied to the prominence of the outer end of the sternal fragment, with a view of forcing it back into place. And this may be done with advantage, provided the reduction has first been completely effected, if the projection still persists. If, however, the cause of the deformity is the pushing in of the inner end of the distal fragment behind the outer end of the sternal—as I believe it to be in the majority of cases—the pressure of a compress can only force back both fragments, and serious harm may result. I have certainly seen it productive of severe pain.

With the view of rendering the fragments immovable, it was proposed by Guérin (de Vannes) to fix the sound arm against the side by means of a body-bandage, and to apply a dextrinated bandage to the head and affected shoulder, the face being averted from the latter. He recommended along with this the use of Desault's apparatus, starched or dextrinated. It is not stated by Malgaigne that this plan was ever put into practice; but probably few patients would be willing to submit to such an encasement, which would involve extreme discomfort.

Malgaigne suggested "surrounding and confining the two fragments by two steel hooks, like the forceps of Museux; just as in the serrated fracture with an angle upward, I thought," he says, "of passing in at the summit of the angle a double hook, which by means of a strap and band could be drawn toward the elbow, thus exerting all the necessary pressure." But he very justly remarks that the idea needs maturing; and I do not know that he ever followed it out any further.

Modern surgery has more than equalled the hardihood of Malgaigne. Langenbuch is reported[3] to have treated a fracture of the clavicle by cutting down upon it, and suturing the fragments together with silver wire, the periosteum being also sewed with catgut. A very just criticism of this procedure has been published[4] by Dawson, who maintains that the results obtained by ordinary means are sufficiently satisfactory to forbid running the risk involved in making the fracture compound, especially in the neighborhood of such important and vulnerable structures.

There are instances, however, in which an operation is entirely proper. Whitson[5] reports the case of a boy, aged fifteen, who was knocked down and run over by a reaping-machine, sustaining a compound fracture of the right clavicle, and a compound fracture of the right humerus. On the sixth day, a thick wire suture was passed through the fragments of the former bone, and good union was obtained.

When, as in the last mentioned case, fracture of the clavicle is complicated by fractures of the neighboring bones, the treatment may be variously modified. Thus Schneck[1] reports an instance in which a little girl five years of age sustained, by the kick of a colt, a fracture of the clavicle near its middle, and of the humerus near the shoulder. Fox's apparatus was applied, and a hollowed wooden splint along the outer side of the arm, with a girth surrounding this and the child's body. The clavicle was united in two weeks, and the humerus in four, without perceptible shortening or deformity.

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[1] Medical News, October 21, 1882.

[2] British Med. Journal, March 3, 1883.

[3] Medical News, Feb. 25, 1882.

[4] Medical Record, May 20, 1882.

[5] British Med. Journal, Jan. 6, 1883.

Having now passed in brief review the principal plans which have been proposed or employed in the treatment of fractures of the clavicle, it remains for me to sum up the subject by a few practical directions. And in the first place I would say that the secret of success lies not so much in the employment of any special method of treatment, as in the recognition of the conditions to be met in each case, and in the adoption of means suited to them—in tact, judgment, and, above all, in careful attention. All fractures of the clavicle are not alike, nor can they all be treated in one way.

When there is much inflammation about the shoulder, as occasionally happens in fractures due to direct violence, the patient should be laid flat on the back, on a firm mattress, with his head low; and local applications, such as dilute lead-water and laudanum, evaporating lotions, or simple fomentations of hot water, should be employed for a few days.

After the inflammation has subsided, if there remain any malposition of the fragments, it should be carefully rectified as far as possible; and to maintain reduction, I think Sayre's plan will be found the most efficient means; but excellent results may be had with either Fox's or Levis's apparatus. Whichever is used must be carefully adapted to the exact requirements of each case. The forcing the elbow forward, so much insisted on by some authors a few years since, is in my opinion a mistake.

Should compresses be required to push back the sternal fragment, I would recommend the use of a well-padded ring, neither too large nor too small, maintained accurately in place by means of the best procurable adhesive plaster.

When an axillary pad is used, it should not be too thick, nor too strongly forced up into the armpit, lest undue pressure be made upon the large nerves. Hamilton mentions a number of instances in which harm was thus done.

Having had no experience in any of the grave complications of fracture of the clavicle, I shall not discuss their treatment. Non-union would seem to be productive in most cases of so little inconvenience, that a resort to operative measures need seldom be had; although the bone is so superficial as to be easily reached, and, if the cervical fascia be not torn, there will be but little risk of deep-seated inflammation.

Fracture of both clavicles would seem to me to be best treated by keeping the patient flat on his back, with an arrangement on the principle of a double truss, to keep the shoulders pressed gently backward. Of course the upper extremities should be kept at the most perfect rest.

Fractures of the Scapula.

The scapula is not often broken, partly by reason of its mobility, and partly because of the degree of protection afforded to its flat portions by the layers of muscle in which it is imbedded, while its spine, its neck, and the coracoid process, are but little exposed to violence. Of the recorded instances, the great majority were in male adults; about one in five were in women. Among the 316 cases of fracture before mentioned as treated at the Children's Hospital in Philadelphia in seven years, the scapula was affected in only three.

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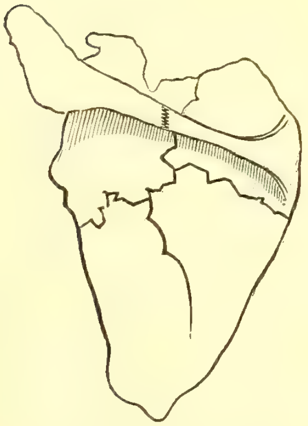
[1] Am. Journal of the Med. Sciences, April, 1858.

In by far the greater number of cases, fractures of the scapula are due to direct violence. There was a man in my wards at the Episcopal Hospital in 1882, who, while working in a dye-house, had been jammed in a narrow space under a roller weighing 500 pounds, by which the body of the right shoulder blade was broken across. Many years ago I saw a railroad laborer who had had the bone comminuted by a blow from the rapidly revolving crank of a hand-car. A not unfrequent cause is a fall from a height, the patient striking on the back and shoulders.

Muscular action has been assigned as the cause of fracture of the scapula in two cases. One of these, quoted by Callaway,[1] as observed by Dr. Heylen, is given in detail, and admits of no doubt; the patient, a man of 49, hung by one hand to a cart while the horse ran a distance of about one hundred yards; the diagnosis of fracture was clear, and there was no bruise or other indication of a blow on the part. The other case is very briefly reported by Mr. M. Morris;[2] it was that of a locomotive engineer, who was making some exertion, and fell forward, striking his chest against the lever; he felt at the same time a crack in his shoulder, and the scapula was found to have been broken. The fracture is said to have been through the spine, about an inch from the triangular surface over which the trapezius plays. Union took place, but a ridge was left at the seat of injury.

Fracture may occur at different portions of this bone. Fig. 605 shows a not unfrequent form, the spine and the body of the bone being affected. As in the case of other flat bones, fissures are often seen in connection with complete fractures. No instance is on record of a fracture involving the spine alone, although the *acromion process* has occasionally been broken off, either by a blow from above, or by the humerus being forcibly driven upward. The *lower angle* of the bone is sometimes separated. When the line of breakage is higher up, it is apt to be more irregular, and the bone may be comminuted. Callaway gives a representation of a fracture produced by the fall of a mass of slate on the patient; one line runs across the bone just below the base of the spine, terminating at the root of the coracoid process, which is broken off; another runs off from near the mid-point of this line, downward and outward to a point perhaps an inch from the lower margin of the glenoid cavity. The bone is thus broken into four pieces: one comprising the upper angle, the spine, and a strip of the body; a second, the lower angle with part of the body; a third, the glenoid cavity, neck, and part of the body; and, lastly, the coracoid process.

Fig. 605.



Fracture of the scapula.

A few instances are upon record in which the *coracoid process* has itself been broken off. One such occurred under my own observation many years since, in the person of an elderly woman, who fell backward in a narrow passage, striking on her elbow, and thus forcing the head of the humerus upward and forward.

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[1] A Dissertation upon Dislocations and Fractures of the Clavicle and Shoulder Joint. London, 1849.

[2] British Med. Journal, Sept. 16, 1876.

Fractures of the *neck* of the scapula have been by some authors regarded as of more common occurrence than they really are. In fact, the neck of the scapula as described by anatomists—the constricted part of the bone close to the glenoid cavity—has never been found fractured upon dissection. A few cases, however, have been studied, and among them one reported, and the specimen figured, by Callaway,[1] in which the line of breakage has run from some point in the upper margin of the bone, so as to include the suprascapular notch and coracoid process, downward and outward to some point in the outer margin, more or less close to the glenoid cavity.

Upon an examination of a normal scapula, it will be found that such a line of separation, running as in Callaway's case for example, first downward and then outward, would surround a portion of the bone which constitutes really its thickest part. A portion of the root of the spine is included in it. By Gurlt and others it is proposed to call this the "surgical neck" of the scapula, while to the narrowed portion just around the glenoid cavity is given the name "anatomical neck." The extreme improbability of a fracture through this last-named part will be obvious at once to any one who looks at a vertical section displaying the arrangement of the bony texture, and who considers the relations it bears to surrounding parts; the former being such as to diffuse as much as possible any stress brought to bear upon the bone, in any way whatever, and the latter being such as to render its fixation, so that a "cross-breaking strain" could be exerted upon it, impossible.

I think, therefore, that it may be asserted that the neck of the scapula, surgically speaking, corresponds to the line above mentioned; and that when fracture occurs in this part of the bone, it follows very nearly the direction thus marked out. With this view clinical facts are entirely in accord.

In order to arrive at a clear understanding of the mechanism of the displacement in fractures of the scapula, the attachment of the muscles to it must be carefully studied. Let it be remembered that this bone finds its sole direct connection with the thorax through its articulation with the clavicle. Apart from this, it is merely supported by muscles.

When fracture takes place across the flat part below the spine, the lower fragment tends to ride up, either in front of the upper or behind it, according to the action of the fracturing force; and this tendency is favored by the contraction of the rhomboidei and teres major; the latter aided by some, at least, of the fibres of the serratus magnus. A number of museum specimens which I have examined, as well as several figured by Gurlt, and two by Malgaigne, illustrate this. In one case, recorded by Easley,[2] where a longitudinal fracture of the body was caused by great violence, the patient having been run over by a wagon the wheel of which passed lengthwise over the scapula, the displacement from muscular action was very marked.

When the upper angle is broken off, the tilting action of the levator anguli scapulæ is quite distinct, as in a bone represented by Gurlt;[3] a gap is even left at the posterior edge between the fragments.

When the fracture affects the body and spine, as in the case seen by me, from which Fig. 605 was taken, the fragments may be so nearly balanced by the contraction of opposing muscles, as to be in reality very slightly disturbed in their relations to one another.

In the cases of fracture of the *neck* of the bone, it appears that there is sometimes very little displacement. Thus, in an instance reported by Ashhurst,[4] in a boy five years old, the diagnosis could only be made by exclusion.

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[1] Op. cit., p. 93. Plate I. fig. 1.

[2] Am. Journal of the Med. Sciences, Jan. 1878.

[3] Op. cit., Bd. ii. S. 528, Fig. 45.

[3] Trans. of Coll. of Phys. of Philadelphia, 3d s. vol. i. 1875.

This may be explained in great measure by the fact that the fragment is supported by the coraco-clavicular and coraco-acromial ligaments, as well as to some extent by the long head of the biceps. But the tendency is for the fragment to be merely tilted downward by the action of the coraco-brachialis, the short head of the biceps, and the middle head of the triceps; with the result of somewhat flattening the shoulder, and thus producing an appearance at first sight simulating downward luxation of the head of the humerus.

This fracture may be, as in the case quoted by Gurlt from Duverney, complicated by fractures of the ribs; and from the violence requisite to cause it, other bones also in the neighborhood are apt to suffer.

Fracture of the *glenoid cavity* has been, in most of the recorded cases, observed in connection with luxation of the shoulder, the latter being the lesion seemingly of most importance. But in one instance, reported by Assaky[1] to the Société Anatomique, the history is given as follows: "A man, aged 65, got a fall, striking his shoulder against a beam lying on the ground; he was taken to the Hôpital de la Charité, where the interne thought he detected and reduced a subcoracoid luxation. About a month afterward the man died of pleuro-pneumonia; and at the autopsy there was found a stellated fracture of the glenoid cavity, the fissures, three in number, extending back into the substance of the neck of the bone, where union had occurred with superabundant callus, composed of fibrous tissue with osseous deposits. A fracture of the acromion also existed, at which suppuration had taken place; there were some irregular bony deposits in the neighborhood."

The *diagnosis* of these fractures has been incidentally referred to in connection with their symptoms. It is generally not difficult to determine the fact of the bone being broken, by the tenderness on pressure, the loss of certain motions of the upper arm—especially those upward and backward, the abnormal mobility of the bone when grasped above and below, the detection of distinct irregularities of outline, and the crepitus elicited, especially by rotating the arm. But to make out the precise line or lines of separation is a matter of far more difficulty. I had in my ward at the Episcopal Hospital, in 1882, a man who had had a heavy beam fall on his shoulder, in whom a fracture could be plainly felt at the posterior edge of the scapula, but it could not be traced any further forward.

Fracture of the *neck* of the bone is distinguished from luxation by the facts that the humerus is freely movable in every direction; that the hand can be placed on the opposite shoulder, the elbow being kept at the side; that the displacement is readily corrected, but as readily reproduced; and that crepitus is present. The analogy between these cases and those of double vertical fracture of the pelvis is very marked.

When the *coracoid process* alone is broken, the fragment can be grasped and felt to be movable upon the rest of the bone; the crepitus, if perceived, gives the sensation of smallness of the surfaces in contact; and the action of the biceps and coraco-brachialis muscles is lost. Hamilton cites a number of instances in which the diagnosis was clearly established, both by himself and by others; and dissections have been made, which set beyond a doubt the fact that this fracture may occur. Yet very careful examination is requisite before it can be asserted to exist in any case.

Fracture of the *acromion*, when it takes place, is not difficult of detection, by means simply of the pain, tenderness on handling, loss of power (from pain), mobility, and crepitus. Many of the museum specimens, which are supposed to exhibit non-union after fracture of this process, are in fact merely examples of want of consolidation of the epiphysis.

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[1] Le Progrès Médical, 11 Fév. 1882.

In regard to *prognosis*, it may be said that fractures of the scapula in general unite readily, and often without perceptible displacement; and that the functions of the arm are seldom permanently impaired.

Very little can be done in the way of *treatment* of these injuries. The arm should be supported with a sling, in such a position as in each case may be found best adapted to obviate whatever displacement exists; and the shoulder should be confined by adhesive plaster applied so as to steady and control the fragments. In fractures of the neck of the bone, an axillary pad may be of service; but it should not be too large, lest it should aggravate, by pressure on the muscles, the very condition it is intended to relieve.

Fractures of the Humerus.

These injuries are by no means infrequent, but the testimony of those authors who have offered statistics on the subject is not uniform; and it is probable that the experience of different surgeons, or the records of different hospitals, would be found, as in other matters, to vary somewhat. Thus Gurlt, quoting those of the London hospitals, says that out of 22,616 fractures treated during twenty years, there were 1651, or 7.3 per cent. affecting the humerus. But Malgaigne, among 2358 fractures observed at the Hôtel Dieu, found 317 of the humerus—over 13 per cent.; and of the 316 cases derived by me from reports of the Children's Hospital in Philadelphia for seven years, there were 72, or about 22.6 per cent. I do not, however, propose to dwell upon these statistical points, and mention them merely in illustration of the difficulty of arriving at conclusions in regard to questions of this kind.

Very marked differences exist between different portions of the humerus in their liability to fracture; but before discussing these, the anatomy of the bone must be briefly sketched.

The *head* of the humerus, nearly hemispherical, looks upward, inward, and slightly backward; a very shallow constriction at its circumference, made apparently deeper by the prominence of the greater and lesser tuberosities, is called the *anatomical neck.* Just below this, beginning at the upper margin of the *tuberosities*, and extending to the insertion of the teres major muscle, is the *surgical neck;* the tapering of this portion of the bone from above downward should be specially noted. Below this is the *shaft;* cylindrical above, and flattening out at its lower part, it widens greatly towards the elbow. The lower end of the bone is turned somewhat forward, and presents the pulley-like surface on which the ulna plays, with a rounded eminence at the outer side of this for the head of the radius. Above the *trochlea*, at the inner margin of the bone, projects the process called the *internal condyle* or *epitrochlea*, and corresponding to it on the outer margin is a smaller prominence, the *outer condyle*, sometimes called the *epicondyle.*

The upper epiphysis of the humerus, which unites with the shaft at about the twentieth year of life, is somewhat dome or cap-shaped, and comprises the head and tuberosities, developing from two centres. The lower epiphysis, having four centres, comprises the portion below the sigmoid cavity, and corresponds quite closely in extent with the articulating portion of the bone, although the epicondyles, internal and external, are on a slightly higher level on either side.

A thorough familiarity with the muscular attachments afforded by the humerus, will enable the student of the fractures of this bone to comprehend much more readily the mechanism of their production, as well as of the resulting displacement. This matter will be further referred to in connection with the fractures of different portions of the bone.

Fractures of the humerus may be divided roughly, and for general purposes, into those of the upper end, those of the shaft, and those of the lower end. Under each of these heads are comprised several varieties, distinct in their anatomical and clinical features. But before entering upon the discussion of these, I would call attention to the curious statistics presented by Gurlt[1] as to the influence of age and sex upon their relative frequency. Of 194 cases of fracture of the humerus, there were—

Between 1 and 10 years of age,	62 cases,	or over 31 per cent.
" 11 " 20 "	42 "	" 21 "
" 21 " 30 "	22 "	" 11 "
" 31 " 40 "	16 "	nearly 9 "
" 41 " 50 "	9 "	" 5 "
" 51 " 60 "	22 "	over 11 "
" 61 " 70 "	16 "	nearly 9 "
" 71 " 80 "	5 "	" 3 "

Malgaigne's statistics present a different view. He says that of 310 cases of simple fracture of the humerus, there were—

From 2 to 20 years of age,	45 cases,	or over 14 per cent.
" 20 " 40 "	80 "	" 25 "
" 40 " 60 "	105 "	" 33 "
" 60 " 80 and over	80 "	" 25 "

The remarkable discrepancy between these two sets of figures must be at once apparent, but I confess that no explanation of it occurs to me.

Now as to the relative frequency of fractures of the various portions of the bone at different ages, Gurlt gives the following:—

Age.	Upper end.	Shaft.	Lower end.
Between 1 and 10	4 = over 6 per cent.[2]	14 = over 22 per cent.	44 = 70 per cent.
" 11 " 20	11 = " 26 "	10 = 25 "	21 = 50 "
" 21 " 30	3 = " 13 "	13 = 59 "	6 = over 27 "
" 31 " 40	3 = " 18 "	5 = over 31 "	8 = 50 "
" 41 " 50	6 = " 66 "	2 = " 22 "	1 = 11 "
" 51 " 60	11 = " 50 "	9 = " 40 "	2 = 9 "
" 61 " 70	8 = " 50 "	7 = nearly 44 "	1 = over 6 "
" 71 " 80	2 = " 40 "	2 = 40 "	1 = 20 "
	48	62	84
			194

The reader will scarcely fail to observe the great preponderance of fractures at the lower end of the humerus in the first two decades of life, and the increase of those of the upper end of the bone between the ages of 51 and 60—the time when, although active pursuits are not yet abandoned, the ability to avoid falls is diminished.

As to the influence of sex, I will merely say that the males are very largely in excess of the females in every portion of Gurlt's table except four; in the first decade of life the fractures of the shaft, and between 71 and 80 years those of the upper end as well as of the shaft, show equal numbers for the two sexes, while in the latter period the only fracture of the lower end of the bone was in a female.

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[1] Op. cit., Bd. ii. S. 653.

[2] It should be noted that the percentages in the above table refer to the *totals for the different ages*, given in the first table quoted from Gurlt.

Fractures of the Upper End of the Humerus.—Fractures of the upper portion of the humerus include those of the head, of the anatomical neck, of the tuberosities (the greater being the only one clearly made out to have been broken off), and of the surgical neck. Under the last head are embraced separations of the upper epiphysis.

Fracture of the *head of the humerus* by itself is certainly very rare. Dorsey[1] speaks of one case seen by him in which the lesion was "within the capsular ligament, the fracture extending through the head of the bone." Gross[2] says that he has seen "an instance of the kind, which had been mistaken by the attendants for a fracture of the acromion process, and the true nature of which was not detected until several years after the occurrence of the accident, when the man, who was upwards of forty years of age, died of disease of the liver. The fracture, as was shown on dissection, had extended obliquely from above downward through the head of the bone; and although it had become perfectly consolidated, there were several rough prominences which, while they unmistakably indicated the seat of the injury, had greatly impeded the movements of the shoulder-joint. The accident had been caused by a fall from a carriage."

Malgaigne records and figures several cases in which the head of the bone was more or less distinctly broken, but in connection with other injuries.

Our sources of information in regard to these lesions (and in fact in regard to very many injuries in the neighborhood of joints) are narrowed by the difficulty of accurate diagnosis. When the patients recover, the real character of the damage done must, of course, always remain open to some doubt. And even dissection, except in cases in which the fatal result has occurred soon after the hurt, may fail to clear the matter up, the condition of the parts being often such as might have resulted from disease, inflammatory or otherwise, altogether independent of fracture.

These fractures would seem to be always due to direct, crushing violence, the head of the bone being, perhaps, most frequently driven against the glenoid cavity, by a force acting in such a direction as to take it at a disadvantage.

A greater or less degree of arthritis of the shoulder must almost certainly ensue, with pain and swelling in the part, and loss of power in the limb. Displacement is not noted in any of the recorded cases, and, if it did occur, would be attributable to the fracturing force, since there is no muscular action which could cause it. Fraser[3] reports a case which he regarded as fracture of the head of the humerus, complicated with a laceration of the axillary vein. The vessel was tied above and below the opening in it, and a portion of bone—exactly what part of the humerus is not clearly stated—was sawed off. A tedious convalescence ensued, but the ultimate result seems to have been excellent. Holmes[4] mentions a case of fracture of the anatomical neck of the humerus, in which a subordinate line of fracture ran upward into the joint. There was partial rupture and obstruction of the axillary artery, leading to gangrene of the arm, and necessitating amputation at the shoulder-joint.

Fractures of the *anatomical neck of the humerus* are by no means uncommon. They are often spoken of as intracapsular, although it is likely that the line of separation seldom lies wholly within the joint. Elderly persons are the most frequent subjects of these injuries, the mechanism of which it is not easy to determine with certainty. My own belief is that a blow either on the front or back of the shoulder, or perhaps the forcing of the humerus upward against the acromion, may in many cases be assigned as the cause.

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[1] Elements of Surgery, vol. i. p. 141.

[2] System of Surgery, 6th edition, vol. i. p. 980.

[3] Lancet, July 8, 1848.

[4] Principles and Practice of Surgery, Am. ed. p. 260.

Very curious displacements of the fragment have been noted. Gross[1] records two: one in which the head of the bone was "turned upside down, the centre of the articulating surface corresponding with the outer border of the shaft," and the other in which the fragment was "tilted over the greater tuberosity against the posterior surface of the bone." Firm union had taken place in both.

R. W. Smith[2] gives some very singular instances: one in which the head of the bone was simply sunk deep into the cancellous structure of the other fragment, and two in which it had been so completely rotated as to have its rounded articular surface applied to the same part; he quotes a third case of the same kind as having been observed by Nélaton, and a fourth as recorded by Malgaigne.

Occasionally these fractures of the neck of the humerus are complicated by actual luxation of the head of the bone downward, or downward and forward. At least two of Smith's cases were of this character. Cock[3] mentions a case treated by Poland, which was thought to be a dislocation into the axilla; but under chloroform a fracture was detected; the head of the bone could not be replaced; and the patient finally left the hospital with the arm shortened about two inches. He is said to have "regained considerable use of the limb." Dr. Fraser, of Michigan,[4] reports a case in which a boy aged 15, being caught in some machinery, sustained, among other severe injuries, a fracture of the anatomical neck of the left humerus, with displacement downward of the head. It is simply stated that the luxation was reduced under chloroform, and that "perfect recovery" took place in forty-five days. Bennett[5] reports five cases of dislocation of the humerus, complicated with fracture, beginning at the anatomical neck and passing obliquely into the shaft, detaching the lesser tuberosity along with the head. He suggests that the luxation occurs first, and that the fracture is produced by pressure against the edge of the glenoid cavity. This explanation is much more probable than that offered by Hutchinson,[6] who thinks that the supposed cases of fracture with dislocation are really instances of fracture very high up, in which the head of the bone has gradually travelled downward to a new articular facet, by what mechanism does not appear.

A case recently occurred at the Pennsylvania Hospital, in a man of about seventy-six, who fell down stairs and sustained a fracture of the neck of the humerus, with displacement of the head of the bone into the axilla, where it gave so much trouble that Dr. Morton excised it; the result was satisfactory.

Fractures of the *greater tuberosity of the humerus* have been observed mainly in connection with other injuries, either fractures of the anatomical neck of the bone, the upper fragment having been forced down into the lower so as to split it, or luxations, in which stress must have been put upon the muscles attached to the process in question. In a few instances, however, the tuberosity has been separated by itself; and in three, according to Gurlt, the *lesser tuberosity* has been in like manner detached. It seems to me that these lesions may be appropriately classed with "sprain-fractures;" and I venture to refer the reader to the very full discussion of them by Gurlt, merely remarking that the influence of muscular action is distinctly traceable in the displacement of the fragments in these cases. R. W. Smith[1] has recorded a case examined by him after death, in which the greater tuberosity, together with a very small portion of the outer part of the head of the bone, had been completely separated from the shaft of the humerus. This portion of the bone occupied the glenoid cavity, the head of the humerus having been drawn inward so as to project upon the inner side of the coracoid process; it was still, however, contained within the capsular ligament. Nothing was known of the history of the injury, which was of ancient date.

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[1] Op. cit., vol. i. p. 981.

[2] Op. cit., pp. 187 *et seq.*

[3] Guy's Hospital Reports, 3d s., vol. i.

[4] Am. Journal of the Med. Sciences, April, 1869.

[5] British Med. Journal, Aug. 28, 1880.

[6] Med. Times and Gazette, March 10, 1866.

In all these cases of fracture occurring in the immediate neighborhood of the shoulder-joint, there is apt to be a very abundant deposit of new bone in irregular, stalactiform shapes, and this is one chief cause of the impaired freedom of motion which generally ensues upon such injuries. In this, as in many other respects, there is a very marked analogy between fractures in this region and those which affect the corresponding portion of the femur.

Along with the separation of the greater tuberosity, and in consequence of it, there is apt to be a displacement of the tendon constituting the long head of the biceps muscle. If the lesser tuberosity is also broken off, the tendon may slip forward and allow the head of the bone to be pushed outward; otherwise the subscapularis will tend to rotate the whole humerus inward, and thus add to the appearance of depression below the acromion, as well as to the increase in breadth of the shoulder.

Epiphyseal disjunctions are sometimes met with at the upper part of the humerus. About the fifth year of life, the head and tubercles become consolidated, and the mass thus formed unites with the shaft at or near the twentieth year. Examination of a vertical section of a young bone shows that the line marking the epiphysis begins at the axillary margin of the head, and runs across, rising slightly toward the centre, in a direction nearly horizontal, to terminate at the outer side just below the tuberosity. Hence it is evident that the epiphysis, like a cap, rests with its concavity upon the convex end of the shaft.

Below this the bone tapers somewhat decidedly; and, as before said, the *surgical neck of the humerus*, in the adult bone, comprises all between the upper part of the tuberosities and the insertion of the teres major, the lower boundary being but ill-defined.

Fractures of this part have so much in common with epiphyseal separations, that I have thought it best to discuss them together, merely pointing out the clinical differences existing between the two.

Bouchut mentions that Foucher saw, in a girl aged 13, the upper epiphysis of the humerus separated by muscular action, in taking a frame down from a wall above her head. An abscess formed, and death ensued in about seven weeks, when the diagnosis was verified by an autopsy. Hutchinson[2] mentions a case in which, by a fall from a mast, both the upper and lower epiphyses of the humerus were detached. A somewhat similar case is reported by Macnaughton Jones;[3] a double fracture of the humerus, near the neck and near the elbow, with separation of a longitudinal fragment from either extremity of the shaft.

All fractures of the humerus between the tuberosities and the shaft proper of the bone, present the peculiarity, that there is a short upper fragment, acted upon by strong muscles, the supra-spinatus, infra-spinatus, subscapularis, and teres minor, the effect of which is to roll the head of the humerus over inward, and thus to tilt up the lower end of the upper fragment, so that its fractured surface tends to look outward. The lower fragment is at the same time drawn inward by the muscles attached to its upper end, while it is pulled upward by the deltoid, biceps (short head), coraco-brachialis, and scapular head of the triceps. Hence, the moment that there is any engagement of the two fragments in their changed relation, the tendency of the muscles is to keep up, and even to increase, the disturbance of the upper fragment.

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[1] Op. cit., p. 178.

[2] Med. Times and Gazette, March 10, 1866.

[3] British Med. Journal, Dec. 24, 1881.

The line of separation in epiphyseal disjunctions has already been spoken of; in fractures through the surgical neck, I think it is, as a general rule, from without inward and downward, or nearly parallel with the plane of the anatomical neck—a circumstance which tends to lessen the degree of the deformity, since the long point of the upper fragment within, and that of the lower fragment without, are in the way each of the other's displacement. When, however, there is an obliquity also from before backward, or from behind forward, the upper fragment may be so tilted as to point outward.

Of this form of displacement one notable example exists in the Mütter Museum, in a specimen of epiphyseal disjunction, the lower fragment overlapping the other inwardly, and in close contact with it, while the latter is so tilted by the action of the scapular muscles, that a space, filled up, however, by callus, is left between the two fragments at the outer part of the fracture.

This is by no means an isolated instance. In the majority of the specimens figured by Sir A. Cooper, Malgaigne, Gurlt, and other authors, and notably in one illustration first given by Moore, and borrowed by Hamilton and others, the same mechanism is clearly traceable; and this evidence is the stronger, in that it is altogether unintentional on the part of those presenting it. Malgaigne, indeed, says: "The upper fragment is in a position answering to the greatest elevation of the arm in its normal state."

A striking illustration of this tilting action once came under my notice in a case of railroad injury, the humerus being crushed to within a few inches of the shoulder. While the patient was being etherized preparatory to the removal of the limb, the point of the upper fragment was repeatedly thrust strongly against the inner surface of the deltoid by the muscles mentioned.

Further confirmation of this view is afforded by the fact that in most cases of fracture in this region there is, after recovery, a limitation of the movement of the arm directly upward, by reason of the approximation of the points of insertion of the scapular muscles to their origins.

Sometimes, along with fractures in this region, the head of the bone becomes dislodged from the axilla. Hingeston's case,[1] in which the neck of the bone was broken into six pieces, which became united again, is a very remarkable one. Dr. J. Watson[2] reports two cases, in both of which the cause of injury was direct violence; in one the fracture was through the surgical neck(?) "midway between the upper end of the bone and the insertion of the deltoid," and in the other "near the tubercles." Reduction was effected immediately in both, without splinting the limb; in the latter case the arm was drawn out at right angles with the body, and the head of the bone coaxed into the glenoid cavity by manipulation with the fingers. Richet[3] has placed on record a case of fracture of the surgical neck of the left humerus, with luxation of the head of the bone into the axilla. Reduction was effected by manipulation with the fingers, a few days after the accident, and ultimately the shape and usefulness of the limb were entirely regained. Norris[4] reports a case under his care, which had been treated for fracture for twenty-six days, when it was discovered that the head of the humerus was in the axilla. No effort was made at reduction. One other case, which had occurred in the Pennsylvania Hospital, reported by Hartshorne, is referred to, as well as others recorded by Houzelot, Dupuytren, Earle, Peyrani, and A. Cooper. Walton[1] has reported the case of a man, aged 48, in whom a fracture of the neck of the humerus was treated, but a dislocation downward was not recognized for ten weeks. Union of the fracture had then occurred, but the displaced head of the bone gave great pain. The reduction was effected by extension continued for three-quarters of an hour, the whole arm being very carefully and firmly put up in splints beforehand. "A good deal of local and general disturbance followed, but at the end of three weeks passive motion was commenced, and at the end of six weeks the arm could be used nearly as well as the other."

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[1] Guy's Hospital Reports, 1st S., vol. v., 1840.

[2] New York Medical Times, July, 1854.

[3] Quoted in Am. Journal of the Med. Sciences, April, 1854.

[4] Am. Journal of the Med. Sciences, Jan., 1855, and Summary of Transactions of College of Physicians of Philadelphia, N. S., vol. ii. No. 6.

The *symptoms* of separation of the upper epiphysis of the humerus are often somewhat obscure. There is pain and loss of power, with some swelling; and a rather rough ridge is apt to be felt across the front of the joint, at which crepitus is more or less distinctly felt on rotating the arm. In the few cases which I have seen, the ridge has been less prominent than it is represented by R. W. Smith in his work; it is due to the projection forward of the edge of the lower fragment. The degree of mobility is not great, and the crepitus conveys an idea of smoothness of the surfaces in contact as compared with those of an ordinary fracture. In making the diagnosis, the age of the patient is an important point to be considered.

Fractures of the surgical neck of the bone are, as a general rule, easily recognized; besides total loss of power in the limb, free preternatural mobility, and distinct crepitus, the exact line of the fracture can often be made out by feeling. Sir A. Cooper has represented[2] a double fracture in this region, but gives no history of the case. Such an injury, probably due to great direct violence, would not be likely to offer any special difficulty in diagnosis, unless the swelling of the soft parts were excessive.

Fractures of the upper portion of the humerus for the most part unite readily, with the exception of those in which there is displacement of the head of the bone from the glenoid cavity. Even when the change of relation between the fragments is most marked, as in the instances before quoted from Gross and R. W. Smith, consolidation seems to have occurred in every instance. And, as a rule, the usefulness of the limb is in great measure regained, although the mobility of the shoulder-joint is of necessity impaired, either as a result of inflammation, or by the change of the points of attachment of the muscles, or by the substitution of some portion of one or other fragment for the head of the bone, in contact with the glenoid cavity.

Non-union is, however, occasionally met with, as in a case recently reported:[3] A girl, aged twenty, had the surgical neck of the right humerus fractured three times, twice by direct violence, and the third time by the stress put upon it in drawing on a tight boot; the fragments remaining ununited, "Mr. Croly cut down on the fracture under the spray, drilled the ends of the bones, and wired them. The case was not a favorable one for the operation, inasmuch as the periosteum was separated to a considerable extent, and the ends of the bones were widely apart. Necrosis setting in, and extensive suppuration and hectic threatening the patient's life, amputation was decided on." The patient was doing well at the time of the report.

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[1] Lancet, Oct. 30, 1868.

[2] Treatise on Dislocations and Fractures of the Joints, p. 433. London, 1842.

[3] British Med. Journal, March 17, 1883.

Compound fractures of the upper third of the humerus are extremely rare, except as the effect of gunshot injury. They are always of grave importance, and may demand excision, or even amputation.

Skey[1] met with a case in which a dislocation of the humerus was reduced; eight or ten days afterwards, a large traumatic aneurism was developed in the axilla, and the artery was tied above and below. After the patient's death, it was found that he had had "a fracture of the neck of the humerus," and that the artery had been "torn across" by the pointed end of the shaft.

In the Museum of St. Bartholomew's Hospital[2] there is a specimen of ununited fracture of the neck of the humerus, with obliteration of the axillary artery by pressure of the lower fragment of the bone against it. The subject, a man aged 75, had received the injury ten years previous to his death.

> "The fracture extends transversely through the humerus, immediately below its head and below the tuberosities; and it communicates with the cavity of the shoulder-joint. A small detached piece of the bone is connected with the synovial membrane. The synovial membrane is thickened, and its internal surface is rough. The axillary artery is obliterated to the extent of half an inch, in the situation in which the end of the lower portion of the bone pressed against it. Immediately above the obliterated part, the infra-scapular artery arises, of its usual size, and pervious. Close to the infra-scapular is the posterior circumflex artery, obliterated in the first half inch from its origin, and then pervious by means of the collateral circulation. About two inches above the origin of the infra-scapular, a large branch arises from the axillary artery; this branch, extending down inside of the arm, was continued into one of the arteries of the forearm, and formed a principal channel for transmitting blood to the lower part of the limb."

The nerves are very rarely injured. One such case is recorded by Berger,[3] in which the musculo-spiral nerve was pressed upon, and paralysis of the parts supplied by it resulted, with some superficial sloughs. The patient, a man, died of malignant scarlet fever.

Treatment of Fractures of the Upper Part of the Humerus.—In fractures near the upper end of the humerus, the proximity of the shoulder-joint, and the danger of its stiffening, should always be borne in mind. When there is much swelling and inflammation, the most prompt and efficient means should be employed to allay it; the patient should be kept at rest in bed, with the arm and hand on a pillow, and hot fomentations should be constantly used. Where the injury has been caused by great direct violence, it may be well even to apply leeches to the part. On the subsidence of the inflammation, the condition of the fragments should be very carefully ascertained, and measures adopted for correcting any displacement that may exist. If this be very slight, as may happen in feeble persons, or when the periosteum is not wholly torn through, the suspension of the arm in a sling, with a small and soft axillary pad, may suffice; or the arm may be confined to the side by a bandage applied around it and the body, the hand merely being placed in a sling.

Some surgeons employ a splint along the inner side of the arm, with a leather or pasteboard cap fitted on the shoulder, the whole being kept in place by a bandage, a few turns of which are carried around the chest.

But in very many instances, in which the upper fragment is tilted inward by the scapular muscles, as before explained, it affords so little purchase that the only efficient method of correcting the displacement is to carry the lower fragment upward, which is best done by putting an angular splint in the axilla, so that one branch of it shall be applied to the side of the chest, and the other along the inner side of the arm. This splint, well padded, may be secured by a bandage, which in the case of very restless patients may be imbued with plaster of Paris or some other solidifying material. Such a splint was long ago recommended by Tyrrell, and has been more recently employed by Middeldorpf, Gély, and others. It is not needful to retain the arm in this position during the whole period of repair, but only for the first two or three weeks, after which a gradual lowering of the elbow may be effected without putting too much stress upon the newly-formed uniting material.

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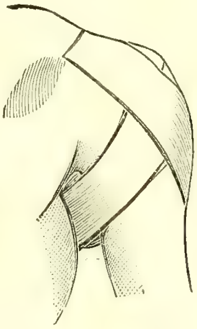
[1] Lancet, May 5, 1860.

[2] Catalogue, vol i. p. 32.

[3] Bulletin de la Soc. Anatomique, Juillet, 1871.

When this splint is used, the binder's board shoulder-cap may be dispensed with. In any case, the cap need extend no further over the shoulder than just to cover in the acromio-clavicular junction. I recently had a woman, aged 57, in my ward at the Episcopal Hospital, who had sustained a fracture of the surgical neck of the left humerus, and in whom the upper fragment projected into the axilla, while the lower was drawn up so as to overlap it at its outer side. I succeeded in overcoming this deformity by means of gentle pressure with a small, firm compress, held in place by a wide strip of adhesive plaster carried around the arm and up upon the shoulder (Fig. 606), the hand being, of course, supported in a sling. The ultimate result of the case I do not know.

Fig. 606.



Application of compress and adhesive plaster to overcome deformity in fracture of the surgical neck of the humerus.

Fractures of the tuberosities admit of very little in the way of treatment, as the purchase afforded by the separated portions is so slight. The elbow, however, should be supported, and the arm placed and kept in such a position as may be found to correct the deformity most completely.

When, along with fracture, there is dislocation of the head of the bone from the glenoid cavity, it becomes a question whether the dislocation or the fracture should be first treated. Cases might be cited in favor of either course; but it seems to me that, as a general rule, an effort at immediate reduction of the head of the bone ought to be made. Such a procedure is certainly difficult; but, on the other hand, the fragments can scarcely be brought into proper relation as long as the head of the bone remains out of the glenoid cavity, and the reduction cannot be easy if put off until after the occurrence of union. Indeed, from the cases quoted on a previous page, it must be evident that a change in the position of the head of the bone is very apt to occur even when there is no luxation. Should the reduction be found impossible, the shaft should be placed in the best attainable position for union between it and the head, in hope that after four or five weeks the attempt may be renewed, with the advantage of the leverage afforded by the length of the bone; although there may be adhesions, changes in the capsule, etc., as in other cases of old luxation, which may foil the best directed efforts. Hence, it must be evident that the prospect in cases of this kind is anything but encouraging.

When, reduction being impracticable, the displaced head gives rise to serious trouble, the proper course is to excise it.

Fracture of the shaft of the humerus is of very frequent occurrence, and is met with at all ages and in both sexes. An instance is reported by Löwenhardt[1] in which a fracture of the upper third of the left humerus took place during the expulsion of a child from the mother's pelvis, the arm lying across the chest; and Hamilton mentions a similar case as having been seen by him, which had occurred in the practice of a Dr. Lockwood, as well as another related to him by Dr. Fanning, of Catskill, N. Y. The latter case was one of head-presentation, and, as the right shoulder passed under the arch of the pubis, a snap was heard, the humerus giving way in its upper third. From Gurlt's table, before quoted, it would seem that females are very much more liable to this injury during the first decade of life than in any subsequent one, while it is most common in males between the twentieth and thirtieth years. Under ten years, the cases in males and females are equally numerous, as they are also after the seventieth year; but in the intermediate period the cases in males are largely in excess. These statements, it must be remembered, are based upon a comparatively small number of cases; but they are sufficiently in accord with ordinary experience to be accepted, although further observation may modify them to some extent.

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[1] Am. Journal of the Med. Sciences, Jan. 1841; originally in Medizinische Zeitung, 6 Mai, 1840.

Under the term "shaft of the humerus," is comprised all of the bone between the lower limit of the surgical neck and the abrupt widening just above the condyles. Every variety of fracture may occur in the region thus included, and from every variety of cause—direct or indirect violence, or muscular action. Fractures from the last-named cause are, indeed, more frequently met with in the humerus than in any other bone in the body.

A thorough knowledge of the muscular connections of the humerus is essential to a proper understanding of the mechanism of the production of these lesions, as well as of the displacements which ensue upon fractures from whatever cause.

The upper extremity constitutes a mechanical system, of which the clavicle and scapula form a part, and in which the humerus is an intermediate lever; the ultimate object of the whole being the discharge of the functions of the hand. The muscles operating this system begin at the spinal column, taking their origin from its whole length, and from this point to the fingers each successive member of the system is in a rapidly increasing ratio of complexity of structure as well as of function, and in a diminishing ratio of mere strength. Perhaps it scarcely needs demonstration that on the humerus, as the only single lever of this system, and the member upon which are exerted the fixing muscles from the trunk, while from it arise the greater part of the moving muscles of the hand, the actions are all concentrated. The exact conditions of the leverage must vary indefinitely with the motions executed by the limb, as well as with the postures it assumes; and in very many of them the muscles passing downward from the humerus combine the arm, forearm, and hand into one continuous lever, in which case the stress upon the humerus must be proportionately increased. Accordingly, the humerus is by far the strongest of the bones entering into the system.

Fractures of the humerus by direct violence need hardly be discussed, as regards the conditions of their production, since these are simple enough. Those produced by indirect violence, as by falls on the hand or on the elbow, or by striking a blow with the fist,[1] are not difficult of comprehension. And the cases of fracture by muscular action, which is generally the effort of throwing, take place in obvious accordance with the laws of mechanics. So many instances of this kind are on record, that it is scarcely necessary to refer to them. I may, however, mention one reported by Lyon,[2] in which a man, aged 30, had "a comminuted fracture of the right humerus, caused by violent muscular contraction in throwing a base-ball by the 'underhand' method. The bone was broken into several parts, extending from the lower to the upper third; besides this, several of the minor bloodvessels were lacerated to such an extent as to threaten gangrene." I know of no other case in which an injury of this kind resulted from such a cause.

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[1] Lonsdale, op. cit., p. 166.

[2] Trans. of Med. Society of Pennsylvania, 1878.

Bellamy,[1] recording the case of a boy of 14, whose humerus gave way just below the insertion of the deltoid, as he was making a great exertion in throwing a cricket-ball, speaks of the twisting motion which is apt to be the finale of this act, as probably the real cause of the breakage; and this view certainly seems to be correct. The suddenness of the stress upon the bone is also to be taken into account.

As to the point at which the bone yields, whether above or below the insertion of the deltoid, this would appear to be determined by slight variations in the character of the movement executed. It must be borne in mind that, in the act of throwing, the humerus is steadied by its upper end against the scapula, its head rolling in the glenoid cavity, while its lower end describes a somewhat large arc, and carries the weight of the forearm and hand, the latter describing the largest arc possible to it. Under these circumstances the bone is acted upon by the deltoid, pectoralis major, and latissimus dorsi, much as the mast of a vessel is by its stays; and it yields just as the latter sometimes does when overloaded above.

By Malgaigne, Lonsdale, and others, cases are recorded in which the humerus has been broken in trials of strength; the opponents "facing one another, their elbows resting on a solid plane, their forearms touching by their ulnar margins, their fingers interlocked, and in this position each tries to turn outward the wrist and forearm of the other." Here the twisting mechanism is so evident that it need hardly be demonstrated.

In one case reported by Mr. Henry Smith,[2] a fracture of the humerus was caused by the attempt of the patient to lift himself by grasping the top of a wall.

Dr. W. B. Hopkins, in a recent article,[3] has reported three instances of fracture of the humerus by muscular action. In one, the patient was throwing a base-ball "over-hand;" in a second, the man made a miss in striking a hard blow at another with whom he was fighting; and in the third, a woman was carrying a heavy tub of clothes.[4]

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[1] Lancet, May 11, 1878.

[2] Med. Times and Gazette, July 25, 1857.

[3] Philadelphia Medical Times, March 24, 1883.

[4] In connection with these cases Dr. Hopkins says:—

"When the forearm is flexed at the elbow-joint by the contraction of the muscles of the arm, the lower end of the humerus acts as the fulcrum, the biceps and brachial muscles as the power, and the hand, with whatever it may grasp, as the weight. The forearm is, in other words, a lever of the third kind. In such the power must always be greater than the weight, technically expressed by the phrase 'mechanical disadvantage.' The amount of mechanical disadvantage to which the muscles of the arm are put to raise a known weight placed in the hand, is computed by multiplying the weight to be raised by its distance from the fulcrum, and dividing the product by the distance of the power from the fulcrum.

"The following measurements were taken from the bones of a well-developed male skeleton: From the bottom of the sigmoid cavity of the ulna to the metacarpo-phalangeal articulation of the middle finger, fourteen inches, and from the same point to the tuberosity of the radius, two inches. (For convenience in computation, the attachment of the biceps alone will be used, as it is the more important flexor muscle, and as it presents less mechanical disadvantage than the brachial.) The power, then, in this lever, is to the weight as seven to one. If, therefore, a weight of one hundred and fifty pounds is raised in the hand by flexing the forearm, the power exerted by the muscles in executing this movement is represented thus: $\frac{14 \times 150}{2} = 1050$ pounds—a force well calculated to part a tendon or break a bone.

"The fact that the forearm cannot be extended with as much force as it can be flexed, though with greater velocity, of course depends upon the difference in distance between the power and the fulcrum in the two cases. For, in the same specimen, the distance from the point of insertion of the tendon of the triceps in the olecranon to a point opposite the bottom of the sigmoid cavity of the ulna, was found to be only half an inch. The power, then, in this lever, is to the weight

One point of importance in the mechanics of the upper arm is the attachment of the forearm muscles, especially the extensors and supinator longus, the action of which, when the elbow is flexed, is to draw forward the lower part of the humerus, and thus to increase the forward angular deformity when this bone is broken anywhere below its middle. The effect of the contraction of these muscles is even more marked, as might be supposed, in fractures near the lower end of the bone, in connection with which it will be again mentioned.

In fractures of the humerus in children, the periosteum, by reason of its comparatively great thickness, may escape complete rupture, and there may be but little displacement. The same is generally the case in adults when the bone is broken by muscular action, or by slight violence. Sometimes, however, the fragments may be very widely separated, and occasionally the overlapping is so marked as to materially shorten the arm. In fractures by great violence, especially if compound, this condition of things may give much trouble. Pierson[1] gives a striking instance of this kind:—

> "A seaman was brought under my care, who, forty-five days before, while at sea, had fallen from the maintopsail-yard upon the deck of the vessel, fracturing the humerus obliquely. The superior fragment penetrated the skin, and, after ploughing a furrow in the plank half an inch deep and two inches long, was finally broken off in it. On my first visit this fragment, which was about three inches long, was presented to me, which the captain assured me he had had much difficulty in extracting, two days after the accident, from the plank in which it had embedded itself."

This man recovered with anchylosis, partial in the shoulder and complete in the elbow; the arm was, of course, shortened.

Syme[2] has reported a case of fracture at or about the middle of the humerus, the head of the bone being at the same time luxated into the axilla. The patient had fallen through a trap-door into a cellar, entangling the arm in a ladder as he fell. Reduction was effected by firmly splinting the bone, and then attaching an extending band above the seat of fracture. The subsequent progress of the case was satisfactory.

The *symptoms* of fracture of the shaft of the humerus are the same as those of the long bones generally: pain, loss of power, preternatural mobility, often deformity, and generally crepitus. Scarcely any fracture is less likely to present difficulties in diagnosis.

As to the *course* of these cases, in most of them union takes place favorably in from four to six weeks; but it must not be forgotten that the humerus has afforded more instances of pseudarthrosis than any other bone in the skeleton. In Agnew's tables, containing 685 cases of non-union, there were 219, or a little less than 32 per cent., in which the humerus was the bone involved. Out of the 219, the exact seat of the lesion is not stated in 52, leaving 167; and of these, 17 are said to have been of "the upper third" or "the surgical neck," and 1 of the external condyle. Hence the shaft of this bone would seem to have been the seat of non-union in 149, or nearly 22 per cent. of the whole number.

Fractures of the humerus in children sometimes unite with great readiness. Thus, among the cases reported by Berry,[3] there were three in which this bone was affected; in one consolidation had occurred on the 11th day, and in the other two on the 13th.

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as twenty-eight to one. Therefore, when a sixty pound dumb-bell is put up from the shoulder, the force exerted by the triceps muscle is shown thus: $\frac{14 \times 60}{\frac{1}{2}} = 1680$ pounds, or 630 pounds more force than is required to raise 150 pounds by flexion."

[1] Remarks on Fractures, Boston, 1840.

[2] Edinburgh Medical Journal, July, 1849.

[3] New England Med. Monthly, March 15, 1883.

It very often happens that fractures of the shaft of the humerus are united with scarcely any perceptible deformity; and in the Museum of St. Bartholomew's Hospital[1] there is a "section of a humerus, in which a fracture of the shaft at the attachment of the deltoid muscle has been exactly united, so that both the walls and the cancellous tissue are uninterruptedly continuous; and except by a slight deviation of its axis, and a small external deposit of new bone, the situation of the fracture could hardly be discerned." Sometimes, however, the deformity is very great, when the fragments are allowed to overlap one another; yet even in these cases the usefulness of the limb is not necessarily impaired.

The vessels and nerves, as a general rule, escape injury, except in cases of compound fracture. Laurent[2] relates one case, communicated to him by Richet, in which a boy ten years old had a fracture of the right humerus, one fragment of which wounded the brachial artery and gave rise to an aneurism, which was cured by ligation of the vessel above and below. Malgaigne quotes two cases in which suppuration ensued; but this is very rare. Instances of the almost complete absorption of this bone after fracture have been referred to in the general part of this article.[3]

Occasionally cases are met with in which, in the course of union of fractures of the humerus, nerves are entangled in the callus or pressed upon by it, with the result of causing pain or paralysis, or both, of the limb. Generally it is the musculo-spiral nerve which is thus interfered with. Trélat[4] reports, that a young man, in consequence of a fracture of the left arm, had an exuberant callus which, by inclusion, caused paralysis of the parts supplied by the above-mentioned nerve. An operation was performed, the nerve being disengaged, and the projecting part of the callus being resected. Two months afterward movements began to be possible, and the functions of the limb were gradually restored. Tillaux is said to have referred to a similar case seen by him.

Gross[5] speaks of having seen two cases of wrist-drop from pressure of callus upon the musculo-spiral nerve, in cases of fracture of the humerus; he says that the only remedy is the removal of the callus, but does not state whether by operation or by local medication; nor does he give the results in the two cases which he cites.

Agnew[6] mentions such a condition, in a boy aged ten years, and says: "As the absorption of the redundant callus took place, and under the stimulus of an electro-galvanic current, his improvement was quite noticeable."

The *treatment* of fractures of the shaft of the humerus is simple enough in principle, but much difference of opinion has existed as to its details. Reduction can generally be effected without great difficulty, and the line of breakage is not often so oblique as to prevent the fragments from being kept in good position. Yet, as has been already stated, no other bone has offered so many examples of non-union. My own belief is that the true explanation of this fact is to be found in the leverage upon the lower fragment, exerted by the forearm and hand, which can only be counteracted by care in securing the whole arm—the upper fragment as well as the lower. No matter how exactly an apparatus is applied, if it does not extend upward sufficiently to get a purchase upon the portion of bone above the seat of fracture, there is danger of deformity, if not of failure of union. But if the fragments are controlled, the forearm may be simply supported in a sling across the front of the chest. I am inclined to urge this, from having more than once or twice seen cases in which angular splints had been carefully bandaged on, but not far enough up the arm; the effect being simply to convert the whole limb below the fracture into a powerful bent lever, by which the lower fragment was moved upon the upper, and the amount of callus augmented, with the chance of deformity, more or less permanent, as well as of entanglement of nerve-fibres, or of interference with the bloodvessels.

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[1] Catalogue, vol. i. p. 139.

[2] Des Anévrysmes compliquant les Fractures, p. 42. Paris, 1875.

[3] See page 45.

[4] Gazette Médicale de Paris, 23 Déc. 1882.

[5] Op. cit., vol. i. p. 976.

[6] Op. cit., vol. i. p. 887.

By the older surgeons, the use of an immediate bandage—a roller applied next to the skin—was considered indispensable for the prevention of muscular spasm. Such a bandage, although less objectionable here than in the case of the forearm or leg, can do no good, and may do harm by hindering the surgeon from accurately judging of the position of the fragments. It is, however, sometimes well to apply a roller to the hand and forearm, and perhaps to include the lower part of the arm itself, in order in some degree to prevent swelling of the distal part of the limb. But the bandage should never be carried up as far as the fracture, and the condition of the fingers should be watched, lest trouble arise from the pressure.

There are no landmarks by which, in the living subject, the proper line of the humerus can be clearly determined. Perhaps as good a test as any is, that the posterior surface of the upper arm being even and vertical, and the thumb held upward, the whole anterior surface of the forearm is in apposition with the side of the chest. Rotary as well as angular displacement is guarded against by observing this position in cases of fracture.

At the back of the arm, the firm and even mass of the triceps muscle, and in front that of the biceps and brachialis anticus, afford an opportunity for making very accurate and effective pressure on these surfaces of the bone. On the inner side, except in very muscular subjects, the projection of the epicondyle is such as to leave quite a marked hollow above it, but on the outer side the hollow, which is much less, is filled up by the deltoid above and by the outer borders of the triceps and brachialis below.

Stromeyer's cushion,[1] a sort of double wedge-shaped pad, upon which, interposed between the body and the limb, the latter rests, is sometimes of great use as a temporary arrangement, but can hardly be relied upon as a permanent dressing.

By some surgeons, it has been thought sufficient to confine the arm to the side by means of bandages, with an axillary pad in the form of a long, flat wedge. In very quiet and submissive patients this may answer; but it is safer to apply also four strips of wood, lightly padded, one on each aspect of the arm, confined either by adhesive strips or by a roller, and then to fasten the whole limb to the chest.

My own preference is for a right-angled splint of wood, extending from the axilla to the ends of the fingers, along the inner side of the limb; the angle corresponding to the elbow, and the arm-part, well padded, so as to allow for the projection of the inner condyle. In the case of a very lean adult, it is better to cut a hole with bevelled edges, large enough to permit the condyle to sink into it and thus escape pressure. Short slips of wood, binder's board or sole-leather, properly padded, are fitted to the anterior, posterior, and outer faces of the arm; the edges and corners of these small splints should be carefully bevelled. Adhesive strips an inch or more in width may be first put on near the ends of the splints, and then an ordinary roller; by this means the occasional removal of the latter for the purpose of examining the limb may be rendered safer. The limb, thus bound up, should be suspended in a sling passing under the wrist; and in children or restless adults, a few turns of a wide roller may be applied to confine the elbow to the side. When the fracture is above the middle of the shaft, the outer short splint may be extended upward into a shoulder-cap such as has already been described, and the roller continued upward, and made to form what is known as the "spica" of the shoulder, a few turns being carried around the upper part of the chest.

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[1] See Fig. 260, Vol. II. p. 158.

Bandages imbued with plaster of Paris, or other solidifying material, have been used by some surgeons in fractures of the shaft of the humerus, but they afford no special advantage, unless, perhaps, in the rare instances where a patient must undergo transportation, or, in the later stages of the treatment, if the dressings cannot be often examined. If applied during the earlier period they need to be carefully watched, lest the swelling of the soft parts should subside, and the requisite control of the limb be thus lost.

Let me again repeat, that the importance of so arranging the dressings as to secure the upper fragment can scarcely be overrated. The inside splint should extend well up into the axilla, only guarding against pressure upon vessels and nerves; and the outer one should bear upon the bone in its whole length. Sometimes additional security may be given by placing on the exposed surface of each of the splints a strip of adhesive plaster, doubled, so as to present its sticky side outward to the roller, as well as inward to the splint.

Sometimes it happens that extension is desirable to prevent overlapping of the fragments of the humerus. According to Swinburne,[1] this is the only thing needful in the treatment of these injuries; and he recommends the employment of an apparatus which certainly has the merit of simplicity. This consists in a board-splint, applied either on the outer, inner, or posterior surface of the arm, and attached to it below by loops of adhesive plaster for extension. Counter-extension is made from the axilla.

Ingenious splints on the same principle, but provided with ratchets for lengthening them, have been devised and used by Lonsdale,[2] Vedder,[3] and others. The objection to all of these lies in the fact that the axilla is made the resisting point for the counter-extension, and that it is wholly unreliable for this purpose.

Harlan[4] obtained great advantage by applying the counter-extending adhesive strips obliquely over the chest and back. He used in one case a wooden splint for the outer side of the arm, with a bracket screwed into its upper end for the attachment of the counter-extending band; and in the other, an iron bar of suitable length, bent at both ends.

Dr. H. A. Martin[5] has employed an apparatus in which, while the counter-extension is obtained by strips applied to the front and back of the thorax, the splint itself consists essentially of a double iron bar, the two portions of which are movable upon one another by means of a ratchet and pinion, worked by a key.

I have myself attained the same object by employing a wooden splint applied to the outer side of the arm, but extending several inches beyond it upward and downward, the counter-extending adhesive strips being simply wound around the arm above the seat of fracture, while the extension was made in like manner from below.

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[1] Treatment of Fractures of the Long Bones by Simple Extension. Albany, 1861.

[2] Op. cit., p. 174.

[3] Vedder's splint may be found described and figured in the Medical and Surgical History of the War of the Rebellion, Part II., Surgical Vol., pp. 812 and 822. There is also here mentioned an ingenious expedient, suggested by Dr. Foster Swift, which consists in fastening together two forked branches so as to get a fork above and another below, to which the extending and counter-extending bands may be attached. Under some circumstances this idea might be carried out with very great advantage.

[4] Med. and Surg. History of the War of the Rebellion, Part II., Surg. Vol., pp. 509, 562.

[5] Ibid., p. 822.

Hamilton mentions that a plan, first suggested and tried by Clark of St. Louis, has been found satisfactory, viz., the attachment of a weight to the lower part of the arm by means of adhesive strips. Without questioning the statements in favor of this method, I must say that it seems to me to present certain practical difficulties in its carrying out, which are not easily met. The humerus must, of course, either be kept vertical, or the weight must pull it out of shape, and when the patient lies down the weight must be suspended over a pulley; but a slight change of posture would interfere with its action, or cause it to make traction out of the proper line.

A very complicated contrivance has recently been described[1] by Dr. Hubbell, of Colorado, having a crutch-head for the axilla, a screw for extension, a splint for the forearm, and a hand-rest; short splints are added if the fracture is not compound. It serves as an instance of the revival of old ideas in a slightly modified shape.

Dr. Hamilton has suggested a method of dressing these fractures, with a view of preventing or curing non-union, which is certainly original, and which can hardly be passed over, although I cannot say that it commends itself to my judgment. After referring to the peculiar tilting motion apt to be impressed upon the lower fragment, he proposes straightening the elbow, and applying a firm, straight splint from the top of the shoulder to the hand, making it fast with rollers. Not only would such a posture be awkward and inconvenient, but the tendency would, I think, be to tilt the upper end of the lower fragment forward, and thus to give rise to deformity.

In fractures near the lower part of the shaft of the humerus, the portion where the bone begins to widen out, there is apt to be a displacement of very marked character from muscular action. The flexors, pronators, and extensors all tend to pull the lower fragment forward, and, as it yields, its upper end must, of course, tilt in this direction; the triceps draws the olecranon upward, and anteriorly the biceps and brachialis anticus do the same. Hence the combined effect of all these forces is to tilt the lower fragment at an angle with the upper, as in Fig. 607. If union takes place under such circumstances, it must be clear that when flexion of the forearm upon the arm is attempted, it will be checked as soon as the coronoid process of the ulna comes in contact with the lesser sigmoid cavity of the humerus, and that in the changed position of the lower fragment the power of full flexion of the elbow must be lost. In order to obviate the tendency to this condition of

Fig. 607.

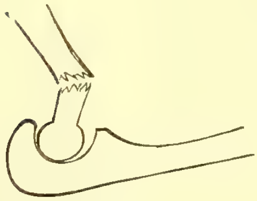
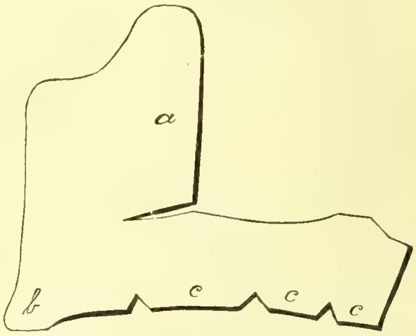


Diagram illustrating tilting of lower fragment in fracture of humerus near elbow.

Fig. 608.



Splint of binder's board for fracture of lower part of humerus.

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[1] Therapeutic Gazette (Detroit), May, 1883.

things, I long ago devised the splint shown in Fig. 608, which is intended to be cut out of the exact size required (ascertained by taking an outline of the sound limb). The material I generally use is binder's board, but sole-leather or patent felt would answer the same purpose, except in the case of unusually large limbs. The part marked *a* is bent so as to come in front of the arm; *b* is bent up behind the elbow, while *c*, *c*, are bent so as to give the forearm support and steadiness on the ulnar side. Properly proportioned and carefully applied, I think that this splint gives me more perfect control of a broken humerus, especially at the lower part of the bone, than I have succeeded in getting by any other. As consolidation progresses, it is my practice to cut away more and more of the splint at each dressing, so that the patient gains the use of the hand before the arm can be left to itself.

Another plan which would seem to promise well, in fractures of the lower part of the humerus, is to place the elbow at an acute angle, and keep it so for perhaps two weeks, when union may be supposed to have begun, and when the forearm may at each dressing be very slightly brought down, until at last the bones are found firm enough for complete passive motion to be attempted. By this method, entire relaxation of the flexors and pronators would be attained, and forward angular displacement could scarcely occur. Should it be found that the lower fragment projected backward, the angle of the elbow might readily be made more obtuse, and a short splint be applied along the posterior surface of the arm.

The subject of pseudarthrosis has already been discussed at such length in the general part of this article, that the treatment of such cases in this region need not be again spoken of here.

FRACTURES OF THE LOWER END OF THE HUMERUS, as has been already stated, and as may be seen from Gurlt's table quoted on page 118, are much more frequently met with than those of either the shaft or the upper end. In children this predominance is especially marked, since up to the tenth year the lower portion of the bone is broken considerably more than twice as often as both the other divisions put together. Between the tenth and the twentieth year the numbers become, in the set of cases upon which this table is based, exactly equal. Later in life there is a very great diminution in the liability of the lower part of the bone to fracture; but the fact must not be lost sight of that the shaft also shares in this decrease, so that the difference of proportion is not as great in reality as it would at first sight appear to be.

The boundary between the shaft of the humerus and what we call the lower end is not exactly defined; even less so, perhaps, than that between the neck and the shaft. It is a surgical and not an anatomical division; and a doubt may sometimes arise in regard to certain fractures, as to whether they should more properly be classed among those of the shaft, or with those of the lower end. But in general the cases which belong to the latter category present features which render them plainly distinguishable. One of these is the effect of muscular action, and another is due to the neighborhood of the elbow-joint; they will be further referred to directly.

Under the present head are included a variety of fractures, the principal lines of which are shown in the annexed diagrams (Figs. 609 and 610). Thus, there are cases in which the bone is separated more or less transversely, just above the condyles, the line of division sometimes running up along the outer or inner side of the bone so as to involve in the lower fragment nearly or quite a third of its length. Often, along with this, one or more lines of breakage pass downward into the joint. Occasionally the outer portion of the lower end only is involved, the condyle only, or with it the epicondyle, being broken off. Or the inner part of the lower end may be separated—the trochlea, with or without the epitrochlea, or the latter process by itself. Finally, there are disjunctions of the lower epiphysis, or of its articular portion only.

It may, perhaps, be as well to say here that although these various forms of fracture can be thus enumerated theoretically, they are not in practice by any means so easily distinguished. The lines of separation may run very irregularly; occasionally the combination of two or more fractures, or the existence of luxation along with fracture, may present a condition of things in the highest degree perplexing. But this matter will be more appropriately discussed in connection with the diagnosis of these injuries. Fractures of the *epicondyle* may, I think, be dismissed without further mention, since there is no case on record in which such a lesion has been verified beyond a doubt. It is true that Zuckerkandl[1] claims to have seen one, and that Gurlt figures a specimen. Sir Astley Cooper[2] also represents one, in which, however, the bone was "somewhat thickened," and the original lesion may have been more extensive. Fresh doubt is thrown upon these specimens by the statement of McBurney[3] that "he had found in the dissecting-room similar isolated pieces of bone resembling detached epicondyles, and existing symmetrically at both elbows." Fractures detaching the epicondyle along with the condyle are, however, known to have occurred in numerous instances.

Fig. 609.

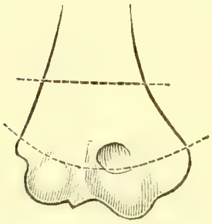

Diagram showing transverse fracture of lower end of humerus. The curved line shows complete epiphyseal disjunction.

Fig. 610

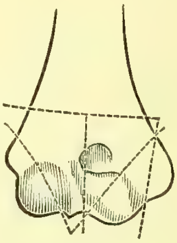

Diagram of T-fracture of lower end of humerus, with lines of fracture of internal condyle or trochlea, of epitrochlea, and of external condyle.

A careful study of the anatomy of the lower end of the humerus, and of the muscles attached to it as well as to the adjoining bones, is essential to the understanding of fractures in this region. Especial attention should be paid to the shape and extent of the epiphysis, in view of the fact that so many of the subjects of these injuries are at an age when it has not yet become consolidated with the shaft, and therefore when the question of its disjunction is apt to arise. The flattening of the bone antero-posteriorly as it widens out toward the condyles, and its consequent thinning, have already been mentioned, as well as the muscles by which the position, bent or extended, of the elbow-joint is controlled.

The epiphysis consists of four parts, developed, according to Gray, in the following manner: "At the end of the second year, ossification commences in the radial portion of the articular surface, and from this point extends inwards, so as to form the chief part of the articular end of the bone, the centre for the inner part of the articular surface not appearing until about the age of twelve. Ossification commences in the internal condyle about the fifth year, and in the external one not until between the thirteenth and fourteenth years. About the sixteenth or seventeenth year, the outer condyle and both portions of the articulating surface, having already joined, unite with the shaft; at eighteen years, the inner condyle becomes joined." (The reader will note that in this description the term "internal condyle" is equivalent to "epitrochlea," and the term "external condyle" to "epicondyle.") The importance of these facts consists in their bearing, not as much upon the separation of the epiphysis as a whole, as upon disjunctions of portions of it, which I have no doubt are more frequent than they are generally supposed to be.

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[1] London Med. Record, May 15, 1878, from Allg. Wiener med. Zeitung, Feb. 1878.

[2] Dislocations and Fractures of Joints, p. 467.

[3] Stimson, Practical Treatise on Fractures, p. 395.

Another matter of great moment in this connection is the anatomy of the elbow-joint. The trochlea, upon which the ulna moves as upon a hinge, drops at its inner margin considerably below the level of any other part of the joint, and thus locks in the articulating extremity of the latter bone. Hence, leverage through the ulna is often brought to bear most powerfully upon the lower end of the humerus, tending to twist it off; and if the epiphysis is yet ununited to the shaft by bone, its disjunction may ensue, while if it has already become consolidated, a fracture may be produced above. The radius, although it shares in the flexion and extension of the forearm, rotates freely upon an axis passing through the centre of its head, and hence is far less likely either to be itself broken, or to be the means of breaking the corresponding portion of the humerus.

As has been already stated, fractures occurring near the lower end of the humerus very often run into the joint; but even when this is not the case, the near neighborhood of the joint constitutes a complication of all these injuries, as its extensive synovial membrane inflames with extreme readiness, and the swelling from effusion into its cavity not only greatly increases the difficulty of recognizing the exact nature of the lesion, but also embarrasses its treatment.

In front of the joint, the median and the musculo-spiral or radial nerve, and behind it the ulnar, are in very close relation with the bone; so that either by actual pressure upon these nerves by the fragments, or by their injury or displacement, special symptoms, of no small importance, are not unfrequently induced.

The *causes* of fracture of the lower part of the humerus are very generally falls on the hand or on the elbow; they are in the former case due to indirect violence, in the latter to direct. Often, however, it is impossible to arrive at any certainty as to the way in which the hurt has been received, from the youth of the subject, or from the confusion and terror induced by the accident. It is highly probable that the tension of the muscles, in the effort to avoid falling, may have something to do with the production of the fracture, or at least with determining its seat and direction. As a general rule, even if in the act of falling the forearm is fully extended upon the arm, it becomes flexed to some degree when the hand strikes the ground; the ulna is forced against the humerus, and held there by the muscles before mentioned, so that there is a combination of leverage and muscular action, to which it is not surprising that the bone should yield. Still another condition favoring fracture is the irregular way in which the force is suddenly brought to bear, so that the stress comes, not in the axis of the humerus, but at an angle to it, as a "cross-breaking strain."

The *symptoms* in these cases, to be appreciated, must be observed at a very early stage, as otherwise the swelling which rapidly comes on, especially if the elbow-joint be directly involved, makes everything obscure, except the fact of fracture. By the direction of the fracturing force, as well as by the muscular action already repeatedly mentioned, the upper fragment generally presents itself, in fractures just above the condyles (to use Malgaigne's term) in front of the lower. Occasionally, but very rarely, the lower fragment is found in front of the upper; this is probably due to the direction of the fracturing force, driving the whole elbow forward. Malgaigne has figured a case of this kind. And in any case, unless the injury has been the result of great direct violence, there is a tendency to the tilting forward of the lower fragment, and thus to the formation of an angle, salient forward. Thus the antero-posterior diameter of the arm just above the elbow is increased in a marked degree. Along with this change in the bone there must be more or less shortening of the arm, although this is seldom sufficient to attract notice. I think, however, that I have observed one sign of this, in the wrinkling of the skin at the back of the arm, just above the olecranon; but this disappears, or at least becomes less distinct, as swelling takes place.

Pain is nearly always present, and may be very severe; it is aggravated by the least motion of the elbow, so that the patient generally supports the arm and hand very carefully with the sound hand. There is, of course, total loss of power, involving the whole limb.

In many of these cases the abnormal mobility is clearly perceptible, and it can almost always be detected upon careful examination. Sometimes, indeed, it is so free as to be in itself puzzling, as in cases where from a transverse fracture there are two or more subordinate lines of breakage running downward into the elbow-joint. Here the sensation imparted to the touch, when the forearm is rotated on the arm, is that of a loose rattling; and, especially if swelling has already begun, it is difficult to get a starting point from which to measure the relations of the fragments.

When, however, there is any lateral mobility of the elbow, the fact of fracture may be regarded as established. In the complexity of the movements performed by the hand, we are apt to lose sight of the simplicity of the parts of the system upon which they depend. At the elbow, in the normal state, there is absolutely no motion except the hinge-like flexion and extension of the ulna upon the humerus, and the rotation of the radius upon an axis passing through the centre of its head, and thence downward through the ulnar border of its carpal articulating surface. When the forearm is semi-flexed on the arm, and the hand moved outward and inward, it seems as if there must be a lateral movement at the elbow, but this appearance will be found to be wholly due to rotation of the humerus around its long axis; the real motion is altogether confined to the shoulder. If the hand can be thus moved when the arm is grasped and held still, it is proof positive of the existence of fracture. Luxation does not free the elbow in any way.

When the upper extremity hangs by the side, with the elbow extended and the hand in supination, it will be seen at once that the elbow forms a very obtuse angle, salient inward, and that the hand hangs out from the side. Now, if without any rotation of the humerus at all, the forearm be fully flexed, it will be found that the hand comes up at the outer side of the shoulder, and that not even by the utmost pronation, with flexion of the wrist, can the end of the middle finger be brought opposite to the mouth. These facts are all accounted for by the outward slant of the trochlear portion of the lower articular end of the humerus, and are of great importance in the recognition, and especially in the treatment, of fractures in this region.

I have already referred to the muscles by which deformity is produced or kept up in fractures of the lower half of the humerus, and need hardly urge that the shorter the lever upon which they act, or, in other words, the lower the seat of fracture, the more direct and decided will be their influence. But it must be remembered that the line of separation of the bone is very seldom directly transverse; even when it runs almost directly across in front, as I have seen in a few specimens, there is apt to be irregularity somewhere in the thickness of the bone, and this gives rise to a lateral tilting, by a mechanism too obvious to need more than mention.

Hamilton[1] has detailed a number of instances in which the ultimate effect of this displacement was clearly shown; and it has occurred to me to see it repeatedly. When union takes place without the correction of this angle forward, the articulating surface of the humerus is directed downward and backward, and the result is that flexion of the forearm is limited, while its extension may be abnormally increased. The reason why extension is not always thus increased, is sometimes the tension of the anterior muscles, the biceps and brachialis anticus, and sometimes the irregularity of the fracture at the posterior part of the bone, just above the joint.

Another effect of the abnormal mobility in question, which has been already hinted at, is the bringing up of the transverse line of the elbow-joint to a horizontal direction instead of the obliquity natural to it. This change is often favored by the treatment resorted to—as was long ago pointed out by Dorsey,[2] and more recently by Allis[3]—the result being to do away with the obtuse angle, salient inward, which the limb should present at the elbow, and to substitute for it a bending in the opposite direction. Such a condition, when existing in a marked degree, produces a very noticeable awkwardness at all times, and interferes with the strength and usefulness of the member in lifting and carrying, as well as in some other of its functions.

So far, I have been speaking only of fractures traversing the humerus just above its lower articulating extremity, whether accompanied or not by fissures running down into the joint. With regard to separations of the outer or inner angles of this extremity, of the epicondyle or epitrochlea, or of the epiphysis, it is impossible to lay down any distinct and definite statements, partly because of the small number of recorded cases, and partly because of the obscurity of the conditions attending these lesions.

As regards the *epitrochlea*, there can be no doubt of its occasional separation from the rest of the bone, the elbow-joint remaining intact. First described by Granger,[4] this lesion has been recognized by Sir A. Cooper, Malgaigne, Gurlt, and others. But, as Gurlt remarks, the line cannot be sharply drawn between cases of this kind and those in which the fracture involves also the trochlea, wholly or in part. Cooper[5] represents a specimen of the latter form of injury; he does not refer to any other, and the only case he records is that of a girl "who, by a fall upon her elbow, had fractured the olecranon, and also broken the internal condyle of the os humeri, the point of the broken bone having almost penetrated the skin." Hamilton[6] gives an account of eleven cases, examined by him at various periods after the occurrence of the injuries. In one only does he state positively that the fracture did not pass into the joint.

Six of these cases of Hamilton's have a special interest in reference to the permanent displacement of the fragment.

1. CASE 45. Examined seven years after the accident. "The apophysis is carried backward about two lines, and upward toward the shoulder about three lines."
2. CASE 49. Examined after sixteen years. "The internal condyle was displaced forward."
3. CASE 51. Examined after three months. "I find a fragment—the apophysis of the internal condyle—broken off, and removed downward toward the wrist one inch and a quarter, where it is immovably fixed."

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[1] Report on Deformities after Fractures. Trans. of Amer. Med. Association, vol. ix. 1856, p. 106.

[2] Elements of Surgery, vol. i. p. 145; also Plate V.

[3] Annals of the Brooklyn Anatomical and Surgical Society, August, 1880.

[4] Edinburgh Med. and Surg. Journal, April, 1818.

[5] Op. cit., p. 466.

[6] Report, etc., before quoted, pp. 110 *et seq.*

4. CASE 52. Examined after five weeks. "The inner condyle is displaced upward three-quarters of an inch. The olecranon process has followed this fragment. Large amount of callus in front at seat of fracture. The elbow is nearly anchylosed at an obtuse angle."

5. CASE 53. Examined after six years. "The internal condyle is displaced downward toward the wrist half an inch." Extension, flexion, pronation, and supination are stated to have been all impaired in this case.

6. CASE 55. Examined after five years. "The inner condyle displaced downward and forward half an inch."

The reader will perceive from the above quotations, I think, more distinctly than from a mere general statement, the influence of the muscles in producing and keeping up displacement of the fragment, when the epitrochlea, with or without part of the joint surface, is broken off. It will be noted that the separated portion had been moved in various directions—backward and upward, forward, downward (in two instances), upward, and downward and forward. When the fragment is drawn upward along the arm, it seems to me that it must be by portions of the triceps and brachialis anticus, the fibres below the fragment being probably torn across. Other displacements may be due to traction by the pronator radii teres, or by the superficial flexors. Very possibly the action is a gradual one, the separated portion of bone being drawn into its new position during the period preceding the organization of the callus. Certainly, in some cases there is at first distinct crepitus, showing that no such gap exists between the fractured surfaces as is brought about afterwards.

When a fracture runs obliquely into the elbow-joint, separating the outer or inner portion of the articulating surface of the humerus, it is not difficult to see how in the former case the radius, and in the latter the ulna, loses its support, and, under the influence merely of the muscles, pushes the fragment before it. Sometimes the fracturing force itself may cause the displacement, and in that case the muscular action would surely tend to keep up the derangement of the parts. An obvious result of either disturbance of relation must be to twist the forearm into an abnormal direction, and, by changing the position of the points of origin of muscles, to interfere with some actions, while others are made more free, although less powerful. Pick[1] has recorded a curious case of fracture of the *external condyle*, the fragment having been carried up and attached to the outer side of the bone. Hunter[2] met with a case in which the external condyle was broken off, the radius and ulna being at the same time luxated outward. The fragment "had apparently become wedged in between the bones forming the elbow-joint," and reduction was impossible. Strength was regained in the joint, but not much motion.

In 1856, I saw a washerwoman in whom a fracture of the *inner condyle* had resulted from muscular effort in lifting a heavy tub. The accident had occurred some two months previously; there was much effusion into the cavity of the joint, and the head of the radius was widely separated from the ulna, but some use of the arm remained. The nature of the lesion was quite clear, and the patient's account of the matter plain and straightforward. I do not know any further history of the case.

Disjunction of the *lower epiphysis* of the humerus is an accident which can of course happen only in childhood or youth. It is probable that here, as elsewhere, the line of separation may not always be exactly confined to the cartilage, but that a portion of the bone may be torn off. On the other hand, I think the fracture may concern a portion only of the epiphysis, and thus be entirely within the joint. The cases of this kind which have come under my notice have been in children, and the mechanism of their production was not known. On passive motion of the elbow, distinct crepitus was elicited, and no other sign of fracture existed except loss of power in the limb, and pain, aggravated by handling; there was no perceptible deformity. The limb was in each case kept at perfect rest by means of an angular splint, and in the two cases of which I have kept notes, complete recovery ensued in about six weeks.

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[1] Trans. of London Pathological Society, 1870.

[2] Philadelphia Med. Times, April 1, 1871.

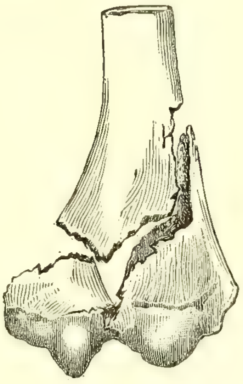
When the epiphysis is separated as a whole, the epitrochlea and epicondyle are of course included in the lower fragment, and the line of division curves downward above each of them, to run almost transversely above the edge of the articular surface. In the cases of this kind which I have seen, the lower fragment has always been carried backward, the radius and ulna following it, and the lower end of the upper fragment projecting somewhat strongly in front of the elbow. I think that the anterior edge of this fragment corresponds pretty nearly with the fold of skin at this point. All motion of the part is painful, and there is especial difficulty in flexion; crepitus is easily detected. The antero-posterior diameter of the joint is increased, and swelling comes on with great rapidity, augmenting the deformity and in great measure obscuring the condition of the parts.

The *course* and *ultimate result* of fractures of the lower part of the humerus is apt to be very unsatisfactory. *Inflammation of the elbow-joint* is commonly set up, and although it may be actively combated, and may not run high, a certain amount of stiffening is almost always induced; this, as a general rule, is in time overcome, but there is often left a tendency to occasional attacks of pain and tenderness.

A curious point may here be noted, namely, that in some cases the stiffening of the elbow may be limited to the ulnar portion of the joint. Thus Lallemand[1] had a patient aged thirty-two years, who, in consequence of a crush of the elbow, opening the joint extensively, had the humero-cubital articulation anchylosed, but the radius was still capable of motion on the ulna, and with some supplemental aid from the shoulder-joint all the motions of pronation and supination were accomplished. In one of Hamilton's cases,[2] a fracture of the inner condyle, he found that "the arm was nearly anchylosed in a rectangular position; pronation and supination were perfect."

The inflammation of the elbow occasionally leads to more serious results. In one case recorded by Wright,[3] a strumous boy, aged twelve, had a fracture detaching the capitellum of the humerus, which gave rise to pulpy degeneration, for which excision of the elbow was performed.

Fig. 611.



Fracture of lower end of humerus.

Perhaps it may be regarded as strange that the *vessels* so seldom suffer in these fractures, but in fact they are not only separated from the bone by a thick layer of soft parts, but are by their flexure in a position to yield readily, and thus to escape tearing. When the fracture is a compound one, however, the course of things may be different. Fig. 611 represents a fracture of the humerus in a boy, aged about twelve, who fell from a low fence; the upper fragment was forced out through a wound in front of the arm, and the artery was torn completely across, rendering amputation necessary.

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[1] Am. Journal of the Med. Sciences, Jan. 1841; from Lancette Française, Mai, 1840.

[2] Report, etc., p. 111; Case 48.

[3] Guy's Hospital Reports, 3d ser., vol. xxiv., 1879.

Sometimes, but more rarely than might perhaps be supposed, the circulation is interfered with by ill-applied apparatus, as in a case recorded by Wright,[1] in which by the pressure of an anterior angular splint, in a case of separation of the lower epiphysis of the humerus, the artery was occluded for twenty-two days; no permanent harm, however, resulted.

Occasionally, serious damage is done to *nerves* in connection with the fractures in question. The close relation of the ulnar nerve to the bone would seem to involve it in constant danger; yet the usual character of the displacement, the lower end of the upper fragment going forward, is obviously such as to diminish the risk. Callender[2] gives a number of cases in which this or the median nerve suffered, and suggests that they may become adherent, and be stretched by sudden movements. Lange[3] has recorded the case of a girl, aged eight, who, after a supra-condyloid fracture of the humerus, had pain at the seat of injury, the wrist and fingers being flexed, with a very limited degree of motion. A sharp edge of bone could be felt. Electricity, massage, and systematic movements were tried for six weeks, at first with some apparent success. An operation was performed, and the median nerve found flattened against the edge of bone; above this point it was thickened and swollen. The nerve was loosened, and the edge of bone excised, with decided relief to the symptoms. "There was one interesting point, namely, that since the operation an entirely different and more normal form of nail was growing, and there were ridges on all of the nails alike, marking the parts before the operation from those afterward. The color and temperature of the skin had also markedly improved."

Another danger in these cases is from the *abnormal or excessive development of callus*, which however happens more rarely here than in some other regions. In the Museum of the New York Hospital[4] is a specimen of T-fracture at the lower end of the humerus, in which the ulna and radius are anchylosed to each other and to the external condyle by bone effused between their contiguous surfaces. A case is recorded[5] in which Mr. Croly excised the elbow-joint of a man about thirty years of age, who had about fifteen months previously sustained a fracture of the joint. A large amount of callus prevented flexion of the joint or use of the fingers. The olecranon, the head of the radius, and the end of the humerus were removed; the coronoid process was left in order to keep the brachialis anticus muscle intact. The ultimate result is not stated.

Malgaigne refers to a case, seen by Monteggia, in which tetanus ensued upon a simple fracture near the lower end of the humerus, and proved fatal, although amputation was performed.

As to the *diagnosis* of these fractures, it presents in some cases little or no difficulty, while in others it is more or less obscure, and occasionally extremely so. Much depends upon the time which has elapsed between the receipt of the injury and the examination, since often a very few hours suffice for the occurrence of such swelling as to completely mask the parts. Under such circumstances the patient should be placed under the influence of an anæsthetic, and the utmost care used in determining whether or not there is luxation of the bones of the forearm—a point which can generally be decided, if in no other way, by the degree to which passive motion can be made. This is a matter of the utmost importance, as the reduction can be far more easily effected at once than at any later period; but its discussion belongs more appropriately elsewhere.

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[1] Ibid.

[2] St. Bartholomew's Hospital Reports, 1870.

[3] New York Medical Journal, April 28, 1883.

[4] Catalogue, p. 68.

[5] Lancet, Feb. 17, 1883.

As a general rule, fractures in this region resemble luxations in the abnormal projection backward of the olecranon; in fact, the two lesions are often undistinguishable from one another by the mere appearance of the parts. (In both, the elbow is slightly flexed; although some authors have represented it as fixed, or nearly so, at a right angle, when luxated. The former has been the position in the eight cases of children and boys which have come under my own observation, and this experience is confirmed by that of Malgaigne[1] and Hamilton. In adults I have seen the elbow quite rigid, and semi-flexed; but the other condition obtains sometimes in them also.) But in case of fracture, if the surgeon places his thumbs in front of the projection of the humerus, he can with his fingers press the olecranon forward into its normal place, and keep it so until he relaxes its hold. Dislocations, I need hardly say, are often very difficult to reduce, and are very unapt to recur.

Dislocation having been set aside, the surgeon's attention should be directed to the allaying of the inflammation by the usual means, the limb being kept in the most comfortable posture; and as soon as possible the attempt to establish an accurate diagnosis should be renewed.

Either before the occurrence of inflammatory swelling, or after it has subsided, the eye may detect certain abnormities in the shape of the limb. One of the most important of these is the increase of its antero-posterior diameter either at or just above the elbow. Another is the change in the relative directions of the axes of the arm and forearm. Still another is a widening of the arm transversely at the elbow. But when either or all of these signs are present, they need to be interpreted by means of further investigation.

If, upon applying the fingers to the bend of the elbow, or perhaps a little above it, the more or less sharp and ragged edge of the upper fragment is felt, the fact of fracture is established; in case of luxation, the rounded articular surface of the lower end of the bone would present itself. The processes commonly known as the condyles, but more correctly as the epicondyle and epitrochlea, should now be found—as they often can be even where the parts are swollen—and pressure made through them across the bone. If pain be thus caused, a fracture running into the joint may be suspected; if crepitus, it may be regarded as certain. Unless swelling have occurred, it may be possible to grasp the epicondyle or the epitrochlea between the thumb and finger, and determine its mobility or fixedness upon the rest of the bone. The attempt may be made also to sway the forearm from side to side, which ought not to be possible. In so doing, crepitus may be elicited.

Upon making passive motion, flexing and extending the elbow, and pronating and supinating the hand, it will be found, if there be fracture, that in one or more of these movements there is crepitation. If this occur in flexion only, or in flexion and extension, it may be that the humerus is simply broken across; but if every motion develop it, the probability is that the joint itself is involved.

Measurement may now be made of the breadth of the joint, from the epicondyle to the epitrochlea, and it may be compared with that of the sound limb. The best means of doing this is of course a pair of callipers; but as these are not likely to be at hand, resort may be had to other methods, the simplest being to apply the back of the elbow to a plane surface, on which a sheet of paper has been placed, and then to put a book on either side of it, standing edgewise on the paper. The distance between the lower edges of the books being marked on the paper, the same may be done for the sound elbow, and the two measurements compared. An increase in the width may be regarded as probably due to fracture involving the joint.

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[1] Op. cit., tome ii. p. 576.

Wright[1] gives two test-lines which may be useful in the diagnosis of injuries about the elbow. He says that it will be found "that a line can be drawn in all positions of the joint, from the most prominent point of the internal condyle, through the upper border of the olecranon, obliquely downward and outward to the head of the radius, and that such line is bisected at a point corresponding to the superior and external angle of the olecranon." The relation of these points to the line would obviously be altered in case of fracture of the olecranon or of the inner condyle. Wright says further: "If also a line be drawn across the back of the joint in full extension, from the external to the internal condyle, or *vice versâ*, that line will lie above the upper border of the olecranon, or, in other words, the angle it forms with the first test-line will be on the distal side of the inter-condyloid line. This line is most conveniently taken by extending the arm horizontally, with the humerus rotated so that the bicipital or anterior aspect looks toward the middle line of the body, and dropping a perpendicular through the condyles."

There is one condition in which the test afforded by these lines would fail, that, namely, of a separation of the articulating portion only of the humerus. Here the relation of the condyles (epicondyle and epitrochlea) to the olecranon would be changed, perhaps indeed in a very slight degree, but still perceptibly; yet the inference that the case was one of luxation and not of fracture would be incorrect. Here, however, the application of the other means of diagnosis, the development of crepitus, and the fact of the ready correction of the slight displacement, together with that of its equally ready recurrence, should suffice to prevent any mistake.

The significance of a change in the relative direction of the axes of the arm and forearm must depend upon the other features of the deformity. If, for instance, the obtuse angle before noted as existing at the normal elbow is done away with, it may be either by a fracture across the humerus just above the joint, or by the separation of the trochlea, or by luxation backward of the ulna and forward of the radius. If it is rendered more acute, there may be fracture of the outer angle of the lower end of the humerus, allowing the head of the radius to slip somewhat backward; or, the humerus being broken very low down, there may be a slight twist of the short lower fragment upon the upper.

The foregoing statement embraces the leading facts in regard to the diagnosis of these injuries; but in practice there are shades of difference in the phenomena presented, which it would be in vain to attempt to set forth. I do not hesitate to say that no class of cases demand more care, tact, and judgment for their detection and discrimination, than those involving the elbow.

As to *prognosis*, the surgeon should always bear in mind the fact that the elbow-joint is apt to be at least temporarily stiffened after injuries in its neighborhood; and that a slight displacement of the fragments, when the lower part of the humerus has been broken, may give rise to a permanent limitation of mobility. Hence he should be very guarded in his promises of complete restoration of the functions of the limb; and it is much better to warn the patient, or the friends in the case of a child, that stiffening of greater or less duration is likely to occur. If the fracture can be clearly made out to be entirely above the joint and above the line of the epiphysis, the prospect for complete recovery is more promising than if the joint be involved; yet even here, unless the tilting of the lower fragment, before spoken of, can be prevented, there will be some limitation of movement. Moreover, this limitation is permanent, and not to be diminished by any treatment; which is not usually the case with mere stiffening of the joint.

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[1] Loc. cit., 3d ser., vol. xxiv. 1879, p. 54.

I have occasionally seen in adults, after injuries of this kind, the stiffening recur from time to time, unless guarded against by continual exercise; and it is, of course, well to mention the possibility of such a result beforehand.

The *treatment* of fractures of the lower portion of the humerus presents difficulties of a very serious nature. Supposing the diagnosis to have been clearly made out, the object of the surgeon must of course be, in accordance with general principles, to correct any existing deformity, and to maintain the fragments in their normal relation until union shall have occurred. But plain as the indications are, the fulfilling of them is by no means easy, nor, as before stated, are the results apt to satisfy either the surgeon or the patient.

The difficulties referred to are four: to keep the fragments in contact and at rest; to prevent the formation of an angle, salient anteriorly; to maintain the oblique line of the articulation by avoiding upward pressure on the inner portion of the joint-surface of the lower fragment; and to obviate stiffening of the elbow.

As to the first of these difficulties, it is due to the extreme shortness of the lower fragment, which gives very little purchase to any confining apparatus; in the case of T-fractures, or separations of the trochlea, the tendency is to a forcing apart of the articulating surfaces, or, what is equally bad, a gaping of the fractured portions above, and, perhaps, the insertion between them of part of the upper fragment. In epiphyseal disjunctions, the correct position of the detached portion is almost wholly a matter of conjecture, and must of necessity be so, until a favorable result affords proof of it. Now, if an anterior angular splint, or two lateral ones, be carefully applied to a sound arm, it will be found that a certain amount of rocking motion can be given, with the effect of loosening somewhat the upper portion of the bandage; should the same thing be done in a case of fracture, it may readily be seen that the part of the limb below the breakage is converted into a bent lever, the short arm of which is the lower fragment; and upon this a very slight amount of force applied to the hand will act most powerfully. Hence, scarcely any good can be expected from means of fixation of this kind, unless bound on so tightly as to endanger interference with the vascular supply, or with the innervation of the limb.

The force of this statement is still greater, if the fact is considered that the parts about the elbow are apt to be largely swollen at the time of the first dressing, and that a daily subsidence of the swelling must be looked for, so that the controlling power of any apparatus is continually becoming less and less, until the inflammation has gone down and its products have been absorbed.

Of the second difficulty I have already spoken at some length, so that it need not be further discussed at present until the details of treatment are taken up.

The third difficulty is one which has been more fully appreciated of late years than formerly. Dorsey, as already said, pointed out the frequent occurrence of deformity from the substitution of an angle, salient outward, for the normal one, salient inward; and Allis has recently, with much force, called attention to the same point. Yet it seems to me that the real source of the trouble is the want of recognition of the obliquity of the line of the articulation, and the application of dressings, no matter in what position—flexed or extended—which press straight across the front of the joint, and thus by their posterior bearings push the trochlea upward, and force the upper and inner angle of the lower fragment past the corresponding portion of the upper fragment, whether behind it or in front of it. Allis's method, putting the forearm in extension, with the normal angle maintained, and keeping the limb in this posture by means of the plaster-of-Paris or starched bandage, or other form of immovable apparatus, is a very sound one in theory, and no doubt has given good results. But I believe that the same advantage may be gained by other means, and perhaps with more comfort to the patient, if only the normal shape of the joint be borne in mind. Any one may readily satisfy himself, by inspection of a sound arm, of the obliquity of the anterior fold of the elbow; and a glance at the skeleton of the limb will show that the line between the bones corresponds with the furrow in the skin.

The means of preventing stiffening of the elbow will be spoken of hereafter.

Now, as to the special plans of treatment of these fractures, they may be classed as those without apparatus, those with apparatus for maintaining flexion, and those with apparatus for keeping the limb extended.

The principle of treatment without apparatus is merely to suspend the limb in a sling, the elbow being flexed, and to favor a certain amount of change of angle of the joint, in order to obviate stiffening. I have heard the opinion expressed by a surgeon of large experience and high reputation, that the formation of a false-joint near the elbow was by no means a misfortune; he had seen a number of cases of permanent disability from anchylosis of the joint, the fractures having united. But I do not believe that it is necessary to run the risk of deformity by leaving the joint uncontrolled, lest it should stiffen; nor does it seem to me that the favoring of a pseudarthrosis to take the place of such a joint as the elbow, is a good surgical procedure. The only proper aim, in dealing with the cases in question, must be to obtain union of the fracture, and to preserve the mobility of the elbow; and my conviction is, not only that these ends can in the majority of instances, by due care and attention, be accomplished, but that any other course would justly fail to receive the approval of the profession.

Various plans have been proposed and adopted for treating these fractures in the flexed position. By some surgeons, a rectangular splint has been employed, extending along the whole posterior surface of the limb; and to this Sir Astley Cooper added an anterior arm-splint to correct the angle forward. Physick's splints, also rectangular, and applied along the lateral surfaces of the arm and forearm, had for many years a popularity in this country, due more to the name of their advocate than to the excellence of the results obtained with them. To these succeeded the anterior angular splint, somewhat hollowed to fit along the front of the arm and upper surface of the supinated forearm.

Physick's splints, as used by him, and I believe by all of his followers, were made of wood: for the others, wood, tin, binders' board, gutta-percha, and felt, have been employed. My own practice has been to use binders' board, shaped as shown in Fig. 608, giving the lower edge of the part applied to the front of the arm an obliquity corresponding to that of the crease at the bend of the elbow, and bevelling it off so as to avoid painful pressure on the skin. The advantage obtained in the pressure of the upper part of the lower fragment backward, while the olecranon is pushed forward by the projection at the angle of the splint, bent around against it, has seemed to me to be very great.

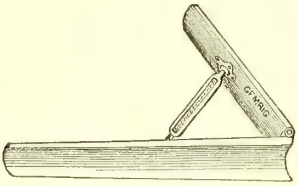
Another plan, which I think would answer well, although it has never to my knowledge been employed, would be to place the forearm in a state of flexion at a somewhat acute angle, keeping the hand semiprone, and directed a little outward, so as to maintain the normal angle before referred to. In this way the projection forward of the upper end of the lower fragment would be in great measure, if not altogether, obviated, since the muscles which cause it would thus be relaxed. The posture, although not as comfortable for a length of time as the rectangular, would still not be unendurable, and would not need to be maintained after the process of union had begun.

The method by extension, advocated by Allis, has already been described. It is recommended also by Ingalls.[1]

A most important matter, in the treatment of all these cases, is the making of passive motion. This ought, in my opinion, always to be begun as early as possible; but the proper time varies with circumstances. When the line of fracture is wholly outside of the joint, and the latter does not become swollen by effusion within its cavity, I think it well at the very first dressing to grasp the lower part of the arm firmly, but gently, and to slowly and quietly make flexion, extension, pronation and supination, not to extreme degrees, but freely enough to exercise the whole joint. Properly done, this process involves no risk of disturbing the fragments, nor is it followed by any pain, tenderness, swelling, or other evidence of inflammation. Even if the joint is involved in the breakage, I think that as soon as the inevitable inflammation has subsided, passive motion may be very gently made, and with advantage; perhaps, at first, the movements may be limited to pronation and supination, and flexion may be added subsequently, extension being postponed on account of the risk of tilting the lower fragment forward. Should marked irritation ensue, it may be allayed by hot fomentations, by poulticing, or by the local use of lead-water and laudanum, and no further attempt should be made for a few days, perhaps for a week.

When stiffening of the elbow has already occurred, whether early or late in the progress of the case, it is very desirable to overcome it; and the means to be adopted with this view must vary according to circumstances. If it is early, an attempt should be made to change the angle from day to day, or oftener. This may be done either by employing different splints, with slightly varying angles, substituting at each dressing a fresh one, or by the use of a single splint with a hinge corresponding to the elbow, and with the two portions movable by means of Stromeyer's screw (Fig. 612). A modification of this appliance has lately been proposed by Keen, consisting simply in attaching the screw by curved arms, so as to place it well over at one side, and avoid interference with the bandaging of the arm to the splint. I think advantage is sometimes gained by poulticing the joint for a day or two previous to attempting to change the angle. Violence should never be used in these cases.

Fig. 612.



Hinged splint for elbow, with Stromeyer's screw.

An important point to be noted is the degree to which flexion can be made, and the character of its limitation. If the forearm is checked at an angle of say 30°, there is reason to believe that the lower fragment is tilted forward; and this is the more likely if extension can be carried beyond its natural limit. In such a case, it becomes a question whether an attempt should be made, under anæsthesia, to correct the abnormal position of the lower fragment, or to do the same thing by gradual means—changing the posture of the limb by dressing it in a state of flexion; or it may be, especially if the previous history of the case shows the joint to be readily inflamed, that the more prudent course will be to let things remain as they are, notifying the patient or his friends that there will, probably, be a permanent limitation of movement.

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[1] Medical News, Jan. 7, 1882.

As extension is made, the degree to which the normal angle between the axes of the arm and forearm has been preserved, should be noticed, and if it has been lost, the propriety of an effort to restore it must be obvious.

Compound fracture of the lower extremity of the humerus, not involving the joint, is of rare occurrence. It differs from simple fracture of the same part mainly in the difficulty of treatment, and in the risk of inflammation of the joint, with consequent stiffening. Almost always due to great direct violence, it may present any of the forms before spoken of, with like displacements.

When the elbow-joint is involved, the lesion is a very serious one, and is extremely apt to be followed by anchylosis, in spite of all the efforts of the surgeon. The fact that the joint is opened is generally revealed by the escape of synovia; but the absence of this symptom does not prove that the joint is intact.

When the external wound is large enough, an exploration may be properly made with the finger; but if otherwise, the ordinary rule should be followed, to close the orifice at once as completely as possible, in the hope that it may heal, and thus render the fracture a simple one. Occasionally, if the bone seem to be extensively smashed, with only a small skin-wound, the latter may be enlarged by incision. The injury to the soft parts is very generally on the posterior face of the limb, unless it be due to the projection forward of the upper fragment, in which case, as in one instance before mentioned, the vessels or nerves, or both, may have sustained damage. Amputation is sometimes unavoidable.

The advocates of Listerism advise that, if the joint has been entered, it should be washed out with carbolized water, with the view of destroying germs, and thus preventing suppuration. I believe that the practice is followed by good results, but not on the theory just mentioned. It is a matter of observation that, when any serous membrane is laid open, pure water applied to it acts as an irritant; and the anæsthetic property of carbolic acid is also a known fact. By virtue of this, a weak solution of the acid may, it seems to me, prevent the inflammatory action which would naturally follow the admission of air to the joint-surface. Dirt or other foreign matter forced in at the time of the receipt of the injury must be carefully washed out, and for this purpose the carbolized water answers as well, if not better, than anything else.

When the fracture, besides being exposed to the air, is comminuted, it is important for the surgeon to see that any loose fragments are removed, and that those that remain are in proper place. Otherwise, even if the joint continue free from adhesions, its motions may be interfered with, and the usefulness of the member be proportionally lessened.

A small wound may be closed with lint and collodion, or with any good, non-irritant adhesive plaster. Another excellent plan is to apply lint saturated with Peruvian balsam. Good results have also been attained by the old plan of saturating lint with the blood, and allowing it to dry over the wound. For the first few days, until the subsidence of the acute inflammatory condition which must attend an injury of this kind, the application of a splint is needless, unless it be merely a wide rectangular one, well padded, upon which the limb can be laid for the purpose of keeping it steady. Irrigation may, in these cases, be sometimes employed with advantage. When the wound has healed or has begun to suppurate, and the swelling has gone down, attention must be paid to the position of the fragments, as well as of the forearm and hand. Anchylosis is so likely to occur, that it is important to arrange the limb in such a way as to make it most useful even with a stiffened elbow; the proper plan is therefore to flex the forearm at an angle of about 90°, and to keep the hand semi-prone.

When the services of a skilled mechanic can be had, some form of bracketed splint, one portion to fit the front of the arm, and the other that of the forearm, may be employed. Or, by a little ingenuity, the surgeon may adapt a strip of tin, of sheet-zinc, or of hoop-iron, so as by means of a plaster-of-Paris bandage to control the limb properly. In either case, a sufficient space should be left opposite the wound for the application of suitable dressings. When there is much discharge, cleanliness requires that the renewal of the dressings should be frequent; and it is well to protect the adjacent edges of a plaster-of-Paris bandage, either by a strip of oiled silk folded over them, or by a coating of varnish.

As to the character of the dressings to be employed, nothing need be said here, the subject having been fully discussed in previous portions of the Encyclopædia.

Before dismissing the subject of fractures of the humerus, I wish to add a case which came under my notice too late to be mentioned in its proper place. It is recorded by Mr. R. Jones,[1] and was that of a man, age not given, who fell from a height, and in falling grasped at a door. He thus sustained a subclavicular dislocation of the right humerus, which bone was broken at the middle, and a dislocation backward of the elbow. The fracture was secured in splints, and the dislocation reduced. Some effusion occurred in the elbow-joint on the third day, but was rapidly absorbed; and the movements of both elbow and shoulder were free and painless in six weeks. He had previously dislocated both hips, and on three occasions the left shoulder.

Fractures of the elbow, properly so called, in which not only the lower portion of the humerus, but the upper portions of the bones of the forearm, are involved, present certain special features which entitle them to separate consideration. They can, however, be more suitably spoken of after the discussion of fractures of the last-mentioned parts.

Fractures of the Bones of the Forearm.

Taken collectively, the fractures of this part of the skeleton constitute a very large proportion of the whole number of these injuries. Wide differences exist, however, between the two bones of the forearm, as well as between the different portions of each, in regard to their liability to fracture. Thus, the ulna by itself is rarely broken, especially at its lower part; the radius by itself is almost exempt above, but fractures near its lower extremity are among the most common of accidents. Both bones may give way at once, to a crushing force, in any part of their length; but more frequently they are broken by indirect violence, somewhere near the middle, or below it.

The order of frequency of these accidents may therefore be stated as follows: The radius alone near its lower end; both bones about their middle third, or in the upper part of the lower third; the olecranon; the coronoid process; the radius alone near its upper end; the ulna alone in its lower part.

Now these differences, far from being unaccountable and as it were capricious, find a clear explanation in the anatomy and mechanical conditions of the forearm and of the bones themselves; as does also the fact, at first sight strange, that the thickest and seemingly the strongest portion of each bone is the one which most frequently gives way.

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[1] Lancet, April 28, 1883.

Fracture of the olecranon is very rare in children, although it is mentioned three times among the 316 cases in the records of the Children's Hospital, before quoted, while Malgaigne quotes three cases recorded at the Hôtel Dieu between the ages of eleven and fifteen. Holmes[1] figures a specimen of "fracture of the cartilaginous epiphysis of the olecranon," but does not mention the age of the patient; the head of the radius was dislocated forward.

By far the most common cause of this injury would seem to be falling upon the elbow, the joint being strongly flexed at the moment. A blow, or any other direct violence, may cause it in like manner. An old woman once came under my care, who had fallen down in ascending a staircase, striking her elbow on a pebble which lay on one of the steps, and breaking the olecranon. Muscular action has been thought to produce this fracture in a number of cases, although Malgaigne, while admitting four, says that "instances of this kind call for careful scrutiny." Dupuytren[2] says: "A sudden and very violent extension of the forearm, by the action of the triceps, may also produce fracture of the olecranon, which happened whilst I was a student, to a person who, whilst playing at tennis, gave the ball a violent back-stroke with the racket, and immediately felt a sharp pain at the elbow. I examined the arm, and found that the olecranon was fractured."

It must be remembered that the triceps is not inserted into the tip of the olecranon, but "into the back part of its upper surface, a small bursa, occasionally multilocular, being interposed between the tendon and the front of this surface."[3] Moreover, the tendon of the triceps, expanding over the upper and back part of the ulna, gets a much larger attachment than merely to the upper surface of the olecranon, and the "tearing off" of this process, described by some surgical writers, is actually impossible. In one case, quoted by Malgaigne from Veyne and Robert, it is said that these surgeons "made out a detachment of the apex of the olecranon;" and this is the only one of the instances mentioned by Malgaigne in which the exact seat of the fracture is stated.

Lonsdale[4] suggests that fracture of the olecranon may sometimes be explained "by the ulna being thrown back against the humerus with great violence, which motion produces extreme extension, and throws the olecranon process forcibly against the humerus, which may be sufficient to break it off from the rest of the bone;" I may say that this idea had crossed my own mind, but that it had seemed to me that the anterior attachments of the forearm, both muscular and ligamentous, would prevent such extreme extension.

The olecranon may give way at either of several points. Sometimes the line of fracture runs through the slightly constricted part which corresponds to the middle of the sigmoid cavity, as looked at from the side. Sometimes it passes across the middle of the process, and occasionally it is much closer to the apex. In one specimen in the Warren Museum,[5] in Boston, there is a double fracture, with close fibrous union. "The lines of fracture are, respectively, $\frac{1}{2}$ inch and $1\frac{1}{3}$ inches from the extremity of the bone; and at this last the union was so close that it only appeared when the pieces were separated by maceration." Very probably there is often a certain amount of crushing of the edges of a fracture produced by direct violence, but the above is the only instance known to me of double fracture.

The direction of the line of fracture varies, although it would seem to be mainly transverse.

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[1] Surgical Treatment of Children's Diseases, p. 265, Fig. 45.

[2] Diseases and Injuries of the Bones, Syd. Soc. Transl., p. 37.

[3] Gray's Anatomy, Descriptive and Surgical, p. 305.

[4] Op. cit., p. 154.

[5] Catalogue, p. 171.

Both olecranon processes are reported to have been broken in one case observed by Mr. Fletcher;[1] the patient was a youth of sixteen, and it seems likely that the lesions might have been more correctly called epiphyseal separations. They were due to direct violence. Hamilton mentions having had occasion to reduce a backward dislocation (of nine weeks' standing) of the radius and ulna in a boy aged seven, in whom the olecranon, still, of course, an epiphysis, was separated by forcible flexion during the operation. He says further: "I have twice since broken the olecranon in attempts to reduce old dislocations of the radius and ulna backward, and I have not regretted the occurrence, since it enabled me to reduce the dislocations without cutting the triceps."

In most cases there is a perceptible gap between the detached portion and the rest of the bone, due in some measure at least to traction on the fragment by the triceps muscle; but there may be so much of the periosteum left intact as to prevent any separation. Cases do occur in which the fragment is drawn up along the back of the arm, but they are more rare than might be supposed. Flexion of the elbow increases the gap when one exists.

Tillaux[2] expresses the opinion that when there is separation of the fragments, it is due not to the drawing up of the upper one, but to the flexion of the elbow, removing the lower one; and cites in proof of this view the fact that the gap disappears when the elbow is again extended.

As soon as there is any separation at the point of juncture, the elbow-joint is of course opened, and, although the injury is subcutaneous, effusion takes place from the torn and irritated synovial membrane; a circumstance which, although it would not in itself suffice to push the fragments apart, certainly does not tend to diminish the gap.[3]

The *symptoms* of this injury are: immediate loss of the power of extending the forearm, and pain in the elbow on attempting to do so; some pain and soreness in the part, although this has not been marked in the cases I have seen; a cleft or gap between the fragments, filled up when wide by a soft, almost or quite painless, fluctuating swelling; generally there is also some bulging of the triceps muscle at its lower part, just above the seat of injury. Lonsdale[4] quotes from Earle the case "of a gentleman who fractured the olecranon, and where the separation did not take place till the sixth day after the injury, at which period it was caused by the patient attempting to tie his neck-cloth." The detached portion can be grasped between the surgeon's thumb and finger, and moved by itself with more or less freedom. Crepitus is, of course, wanting unless the fragments are in contact; and the smaller the portion broken off, or, in other words, the nearer the fracture is to the summit of the process, the less likely is it that the surfaces can be rubbed upon one another. Ecchymosis is very commonly present, and may gradually extend along the ulnar margin of the forearm for several days.

These symptoms may vary considerably in distinctness, but they are, as a general rule, well enough marked to make the *diagnosis* clear. Bransby Cooper[5] saw a case in which the power of extension of the forearm was so far retained as to give rise to much doubt.

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[1] Med. Times and Gazette, Aug. 16, 1851.

[2] Anatomie Topographique, p. 578.

[3] In this respect the olecranon differs from the patella, which is of less size as compared with the knee-joint. In fractures of the latter bone, it is held by some high authorities, that the separation of the fragments depends largely upon the free effusion of liquid into the articular cavity. But the patella clearly belongs among the "sesamoid" bones, while, according to Owen (Gray's Anatomy, p. 135, *note*), the olecranon is homologous with an extension of the upper end of the fibula above the knee-joint, which is met with in the Ornithorhynchus, Echidna, and some other animals.

[4] Op. cit., p. 156.

[5] A Treatise on Dislocations and Fractures of the Joints, by Sir Astley Cooper. Edition of 1842, p. 471.

Fractures of the olecranon are, for the most part, united by fibrous tissue only, the length of the band, as well as its thickness, varying in different cases. Yet there are many instances on record of true bony union; and this might be much oftener obtained, but for the difficulty of keeping the fragments in complete apposition. In Fletcher's case of fracture of both olecranons, before quoted, this result took place on each side, as proved by dissection after the patient's death nearly a year subsequently.

When osseous union occurs, there is on the outer aspect of the bone a deposit of callus, which gradually becomes absorbed; on the articular surface there is, as in other cases of fracture running into joints, a depression or groove marking the line of the fracture. In the case of ligamentous union, there are sometimes numerous bands passing from one fragment to the other, sometimes two or more at either side, and occasionally a thin membrane-like sheet, apparently derived from the periosteum.

A curious specimen exists in the Warren Museum,[1] of "a piece of bone broken from the olecranon, and fifteen years afterwards removed from the elbow-joint." It seems probable that this was a fragment from a comminuted fracture, torn away entirely from its fibrous connections, the remainder of the bone having become solidly united; but the account is not as full as it might be.

The difficulty often met with in maintaining the contact of the fragments, is due to several circumstances. One of these is the contraction of the triceps muscle, which, when the fibrous tissues surrounding the bone are torn through, must tend to draw the fragment up along the back of the arm, tilting it at the same time so as to widen the gap posteriorly. Another is the effusion which takes place in the joint, and which may be very copious. Still another is the upward traction not only of the triceps, but of the biceps and brachialis anticus (the latter especially), tending to crowd the end of the humerus between the fragments. All these belong especially to the early period, and vary in their degree in different cases. Sometimes the smaller fragment, drawn upwards, contracts adhesions in its new position, and thus, when swelling has subsided and muscular contraction has been quieted, may resist all efforts at bringing it down.

The result of experience is that the usefulness of the limb after a fracture of the olecranon is not dependent altogether upon the shortness of the band uniting the fragments. Even if union is effected by bone, there may be adhesions within the joint, or about it, limiting the movements of the forearm upon the arm. And, on the other hand, it sometimes happens that, although the separation of the fragments is considerable, the freedom and strength of the limb are but little impaired. In most of the ordinary functions of the hand, active extension of the elbow is less indispensable than flexion.

The analogy between fractures of the olecranon and those of the patella, in regard to the recovery of function even with a fibrous connection of some length, will be pointed out in connection with the account which will be given of the fractures of the latter bone.

Absorption of ligamentous union is recorded in one case by Mr. B. Cooper.[2] He says:—

> "The patient should be cautioned against using his arm too freely, till the uniting ligament has acquired strength and firmness. A patient of Mr. Mayo's, whose olecranon had been fractured, and had united in six weeks by a ligament of the ordinary firmness, suffered severely from neglecting this precaution; for after using the arm as much as possible for some time, he found that it became weaker and weaker; the uniting liga-

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[1] Catalogue, p. 171.

[2] Op. cit., p. 475, *note*.

ment was entirely absorbed, so that the fractured olecranon was drawn up by the triceps, the power of extending the elbow was almost lost, and the limb became wasted and useless."

The time required for the union, whether fibrous or bony, of a fractured olecranon, must vary somewhat, especially in the former case. About six weeks may be stated as the average period. When the fragments are united by bone, the strength of the limb is soon regained, and less caution is needed than if they are joined by fibrous tissue only. Such cases as that of Mr. Mayo, just quoted, are extremely rare; yet the stretching of newly-formed ligament may impair greatly a result which, if the tissue had time to gain strength, would be satisfactory.

Anchylosis of the elbow-joint sometimes follows fracture of the olecranon, and the chance of its occurrence, although remote, is one which ought always to be borne in mind. Some degree of stiffening is very common, but usually disappears without special treatment; it depends upon the thickening and contraction of the fibrous tissues about the joint, as well as upon loss of tone in the muscles from want of exercise. When adhesions occur within the joint, they may be the result of inflammation due to the severity of the original injury; but there can be no doubt that they may be also occasioned by injudicious treatment, and that they are very apt to end in fixation of the parts. The means of avoiding this very unpleasant issue will be presently discussed.

The *treatment* of fracture of the olecranon consists in placing the arm in such a position as to facilitate bringing the fractured surfaces in contact, and confining it so until union shall have taken place. When there is very little separation the surgeon's task is simplified, as it is also by the absence of high inflammatory action in the joint. Yet it must be remembered that without the further advantage of proper care, stretching of the fibrous tissues connecting the fragments may take place, and the ultimate result be unsatisfactory.

For the first few days the arm should be laid in an easy position, with the elbow well extended, and means taken to allay any inflammation that may arise. I do not think that anything is gained by bringing the upper fragment down until all effusion into the joint has subsided; but, after this, the earlier and the more completely it is done the better. Of course, if no inflammation is set up, and the joint does not swell, there is no reason for waiting.

Modern surgeons are agreed that the best results are obtained by placing the forearm at a very obtuse angle with the arm, and keeping it so by means of an anterior splint. The splint should extend well up towards the shoulder, and far enough down to thoroughly control the forearm; I think it should go down into the palm of the hand, so as just to allow of flexion of the fingers. An ordinary roller, snugly applied, suffices to keep it in place. As to the material for the splint, it may be of wood, binders' board, or felt; tin, which answers very well when properly shaped and fitted, has the great advantage of not adding much to the bulk of the limb, and thus of allowing a loose sleeve to be slipped over it.

Some surgeons employ the plaster-of-Paris or starched bandage, but I cannot see that it is of any especial use in these cases. A skilfully applied roller will remain in perfect efficiency for three or four days, and the whole apparatus should be removed at least as often as this, for the purpose of ascertaining the condition of the parts.

Various devices have been employed or recommended for the purpose of preventing the retraction upward of the upper fragment in these cases. Figure-of-8 turns of a bandage, with or without the previous application of a compress, have often been used. Hervez de Chégoin[1] employed with success an elastic compress, drawn downward by tapes attached to the lower end of a hollow, jointed splint.

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[1] Am. Journal of the Med. Sciences, July, 1848; originally in the Gaz. des Hôpitaux.

Sir A. Cooper,[1] who advocated the straight position, advised that after bringing the fragment into apposition with the ulna, a piece of linen should be laid longitudinally on each side of the joint, and wetted rollers applied above and below the elbow; the extremities of the linen were then to be doubled down over the rollers, and tightly tied, so as to cause approximation. It is not distinctly said that he ever used this plan, which would seem to involve great discomfort at least to the patient, as well as risk of interference with the nutrition and innervation of the distal portion of the limb. This objection, indeed, holds good with regard to all the figure-of-8 and other bandages which encircle the limb; if tightly enough applied to be efficient, they may do harm.

With the excellent adhesive plaster now procurable, it is easy to keep the fragment in place without any such binding; a strip of suitable length and width being put on so that its middle shall press just above the fragment, while its ends are carried down along the ulnar side of the forearm, one in front and the other at the back, far enough to take a firm hold. The splint and bandage are then applied as before directed. A compress is needless, and might indeed do harm by tilting the fragment, so as to produce a condition such as Malgaigne quotes as seen by Pasquier: "the fragments, farther separated posteriorly than anteriorly, were only in contact by their anterior edge."

It has been suggested by myself,[2] as well as by others, that in cases of much difficulty an instrument analogous to Malgaigne's patella-hooks might be used —a small metallic plate or wire frame, with either one or two short recurved hooks, to be inserted into the posterior and upper part of the olecranon, drawn down, and fastened in place by means of a strip of adhesive plaster carried along the forearm, as before described. Such a contrivance could be readily made, and probably could be used without danger; yet I think that the majority of surgeons would be content with the results procurable by less formidable appliances.

Dieffenbach,[3] many years ago, proposed and practised the division of the tendon of the triceps, bringing the upper fragment down into place, and occasionally rubbing the two fragments forcibly together; he claimed to have obtained firm union in this way.

Suturing the fragments has been proposed, and the operation has been performed in a number of instances. Mac Cormac[4] and others have thus obtained bony union in cases attended with marked separation. Sheldon had already, in 1789, proposed the laying bare of the bone and rasping of the fractured surfaces, but says, in his work,[5] that he never had attempted the operation. The introduction of the wire suture made the procedure far more effective, and the advocates of the so-called antiseptic system claim that their precautions make it safe. I must confess that no case has ever come under my own observation, in which it has seemed to me that the amount of advantage likely to be derived from such severe measures would warrant their substitution for the less brilliant methods above described. By care and accuracy in the adaptation and use of simple apparatus, satisfactory results can, as a general rule, be obtained.

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[1] Op. cit., p. 474.

[2] New York Medical Journal, Dec. 1866.

[3] Casper's Wochenschrift, 2 Oct., 1841.

[4] Trans. of Clinical Society of London, vol. xiv., 1881.

[5] An Essay on the Fracture of the Patella, or Knee-pan; containing a new and efficacious method of treating that accident: With Observations on the Fracture of the Olecranon. By John Sheldon. London, 1789.

Compound fracture of the olecranon is occasionally met with. Its gravity must depend, in a measure, upon the possible admission of air into the joint, or the effusion of blood into that cavity, either of which occurrences would be of serious import as to the prognosis and treatment of the case, by reason of the inflammation likely to ensue. When the synovial membrane remains intact, the wound must be closed, and the fracture dealt with as in ordinary cases; when the joint is laid open, it ought to be carefully cleansed with carbolized water, and all inflammation allayed by appropriate means before splints are applied. Anchylosis is very apt to ensue under such circumstances.

FRACTURE OF THE CORONOID PROCESS of the ulna is a lesion usually described as very rare, and it has certainly been very seldom recognized as occurring by itself. It may, however, be questioned whether it does not sometimes attend backward luxations of the forearm, as in a case reported by Sayre.[1]

The first published observation of this lesion, according to Malgaigne, was that of Brassard, in 1811. The patient had fallen, three months previously, on his outstretched hand; the motions of the forearm were all free and painless, except flexion, which was limited. "In front of the ulna, between it and the end of the humerus, was found a hard body, somewhat movable, against which the ulna was arrested when the attempt to flex the forearm was made." Dorsey,[2] in 1813, says:—

> "The coronoid process of the ulna, Dr. Physick has once seen broken. The symptoms resembled a dislocation of the humerus forward, or rather of the forearm backward, except that when the reduction was effected the dislocation was repeated, and by careful examination the crepitation was discovered."

Hulke[3] mentions the case "of a man killed by a fall from the roof of St. George's Hospital, in whom the coronoid processes were found to be fractured, and the two bones of the forearm dislocated backward, on both sides." Bradford[4] has reported the case of a man, aged twenty-four, who fell a distance of forty feet, and died of his injuries, among which was a fracture of the coronoid process of the ulna, part of the trochlea of the humerus being also chipped off. The main symptom is stated to have been constantly recurring dislocation backward. Sir Astley Cooper's two cases,[5] one of which was verified by dissection, are well known. In the account of the latter, it is stated that the coronoid process "had been broken off within the joint," which is obviously an anatomical impossibility, although the fracture must of course have entered the joint. Another very often quoted case is that of Liston, in which a boy aged eight sustained the injury by hanging by his hand from the top of a high wall, afraid to drop down.

Fahnestock[6] reported the case of a boy who "fell from the haymow, and received the whole weight of his body on the back part of the palm of the left hand, whilst the arm was extended forward, by which impulse the coronoid process of the ulna was displaced;" the limb presented the appearance of one in which the forearm was dislocated backward, but on being reduced the deformity recurred, and the recurrence was attended by an evident crepitation. It is stated that the boy "recovered very speedily," but the degree to which the power of flexion was restored is not noted. Duer[7] saw a boy, aged six, who, seven weeks before, had fallen from a haymow and dislocated the forearm backward. The displacement still existed, "and the arm being somewhat flexed, the detached portion of the coronoid process lying in front of the joint could be distinctly felt, and freely moved in any direction over a small space." Every effort at reduction failed, and the case was dismissed, pronation, supination, and extension being unimpaired. Gross[1] mentions a case reported to him by Dr. Scott, of Missouri, in which "the coronoid process formed a distinct prominence upon the anterior and inferior surface of the humerus, a short distance above the joint, movable from side to side, the olecranon being at the same time displaced slightly backward, and the forearm somewhat flexed. The accident was caused by a fall upon the hand while the forearm was forcibly extended." In Sayre's[2] case the fragment was adherent to the anterior surface of the (inner?) condyle of the humerus. He refers to a specimen of Dr. Darling's, showing this condition of things, and to another in which ligamentous union had occurred. The latter was obtained in the dissecting room, and was without history. Bryant mentions and figures a specimen in which the coronoid process and the anterior margin of the head of the radius were detached in an old woman by a fall; the fractures were compound, and amputation was performed.

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[1] Transactions of Med. Soc. of State of New York, 1871.

[2] Op. cit., vol. i. p. 152.

[3] Holmes's System of Surgery, 3d edit. vol. i. p. 162.

[4] Boston Med. and Surg. Journal, July 17, 1883.

[5] Op. cit., p. 469.

[6] Am. Journal of the Med. Sciences, May, 1830.

[7] Ibid., Oct. 1863.

From the foregoing quotations it will be at once perceived that the fracture in question may occur at almost any age, and has been ascribed to very various causes. I do not think it needful to discuss the correctness of the diagnosis in each case, as Hamilton has done, because the fact that the lesion occurs has been placed beyond doubt; and for practical purposes this is sufficient. Equally useless is the enumeration by Lotzbeck[3] of twenty-four varieties of the injury. There can be no difficulty in understanding how, if the ulna is forcibly driven upward against the humerus, in any position, but especially in extension of the forearm, the coronoid process as a whole, or its tip only, may be split off. In the case of muscular action, as in the boy seen by Liston, the muscles arising from the inner side of the lower part of the humerus would pull the coronoid process backward against that bone, while the brachialis anticus would tend to drag it away from the body of the ulna. And a glance at a longitudinal section of the upper part of the ulna will show at what a disadvantage the cancellous structure of the base of the coronoid process would thus be placed, and how readily its separation might be brought about.

The cases of this fracture may be practically divided into two classes, according to the extent of the portion detached. If the tip only of the process is broken off, the fragment will be very small, and there will be no marked separation, except by the slipping backward of the ulna, and the consequent relative forward displacement of the humerus, limited by contact with the head of the radius. But when the whole of the coronoid process is split off from the ulna, the action of the brachialis anticus will serve to draw it upward, and the gap between the fractured surfaces will of necessity be more considerable.

Perhaps yet another division might be made, of those cases which are complicated by fractures of other bones in the neighborhood, as when the olecranon also is broken, or when, as in one of Sir A. Cooper's cases, the external condyle has been likewise separated. But here the fracture of the coronoid would as a general rule be the less important injury, and hence it would be more properly assigned the secondary place, as being itself a mere complication of the graver lesion.

The *symptoms* of fracture of the coronoid process have already been given incidentally. The power of flexing the elbow must be more or less seriously impaired; pain in attempting this motion, and tenderness in front of the joint, with occasionally the perceptible presence of the fragment, are to be looked for. Crepitus, if it exist at all, can be but slight. A tendency to luxation backward of the ulna may exist, but can hardly be marked unless some loosening of the attachments of the head of the radius has also occurred.

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[1] Op. cit., p. 697.

[2] Loc. cit., p. 108.

[3] Noticed in Schmidt's Jahrbücher, 1866.

The *diagnosis* may sometimes be very obscure, and only to be arrived at by exclusion. Separation of the articulating portion of the lower epiphysis of the humerus might induce symptoms almost identical with those of this lesion, although in the former case it is probable that the interference with flexion alone would be less distinct.

The *treatment* of fracture of the coronoid process consists simply in flexing the forearm upon the arm, at an angle of about 90° or less, and securing it in this position by means of an anterior angular splint. Pressure should also be made upon the olecranon by applying the middle of a strip of adhesive plaster around it, and carrying the ends forward to be secured to the splint over the forearm; in this way the tendency to displacement of the forearm backward may be overcome with more certainty than by the turns of the bandage, which may slip and become loosened.

Especial care is to be taken in the treatment of cases in which the whole process is separated, as the action of the brachialis anticus will tend to draw the fragment up along the front of the arm, and permanent impairment of flexion must be expected. If the tip only is broken off, it will be subject to no such traction, and the fragment can only give trouble either by being entangled in the joint, or by adhering to the anterior face of the humerus just at its lower end. When the process is drawn up, it may be carefully coaxed down by the surgeon's fingers, and perhaps the pressure of the splint may keep it in place; or the forearm may be flexed at an acute angle so as to let the lower fragment follow the upper. Doubt must always exist, however, as to the efficiency of any treatment adopted, until the patient attempts to resume the use of the limb; and the prudent surgeon will be chary of giving assurances which the result may not justify.

Fractures of the head of the radius are very rare, unless along with other severe injuries of neighboring bones. Bryant's case has already been mentioned, in which the coronoid process of the ulna was also broken off. Malgaigne could only cite two cases, in both of which there was also fracture of the coronoid, and backward luxation of the elbow. The head of each radius was split longitudinally in Hulke's case of fracture of both coronoid processes, referred to on a previous page.

In the Warren Museum[1] there is a specimen (No. 1026) of "one-third of the head of the radius broken off, with a comminuted fracture of the upper extremity of the ulna," taken from a man who had fallen from the roof of a house. Another (No. 1031) is described as "longitudinal fracture of the head of the radius, with fracture of the ulna from the coronoid process downward;" and further as "a clear and regular split, involving very nearly one-half of the head of the radius, and cleaving outward so as to extend no further than the neck of the bone." Stimson[2] saw a fracture of the outer half of the head of the radius, produced by direct violence and followed by suppurative arthritis, in a boy aged thirteen; the excision of the joint enabled him to establish the diagnosis. Adams exhibited to the Pathological Society of London[3] a specimen in which several fissures radiated from a point just below the head of the radius upward to the articulating surface; the injury was the result of a fall from a height.

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[1] Catalogue, p. 172.

[2] Op. cit., p. 433.

[3] Transactions, vol. xxii. 1871.

Other cases, followed by recovery, and hence open to some doubt, have been reported.

The *causes* of fracture of the head of the radius are those of similar injuries in the other bones of the same region; cases resulting from blows, falls, in which there is sometimes a doubt whether the violence has been direct or indirect, and railroad crushes, have thus been observed. In Hulke's case, affecting both arms, it can scarcely be doubted that there was indirect violence; in Bryant's, it is distinctly stated that the woman had a fall, striking on the elbow. But in either class of cases, the mechanism is readily enough explained.

As to the *symptoms*, they are by no means as clear as might be supposed, in view of the ease with which the head of the radius may be felt in the normal state. Pain, loss of power of rotating the hand, as well as of flexing the elbow, crepitus on passive motion, very rapid swelling, and synovitis of the elbow, are quite sure to occur; but the determination of the exact nature of the injury is not so simple a matter, especially in view of the fact that in so many of the recorded instances other lesions have also been present.

The *prognosis* of these cases must, of course, depend, in some measure, upon the amount of damage done to the joint, and to neighboring parts, as well as upon the success of efforts directed toward allaying inflammation. A considerable degree of stiffening may always be looked for, and this, in some cases, will be permanent.

As to the *treatment*, the first object must be to keep down inflammation in the joint, by the usual means, the forearm being semi-flexed. Nothing can be done in the way of correcting displacement, should such exist, which does not seem to have been the case in any of the recorded instances. The limb should be placed in the posture which affords the greatest ease, and lightly bound to a well-padded, angular splint. Passive motion should be attempted at about the tenth day, and repeated every twenty-four or forty-eight hours; the movements should be made with the utmost gentleness, but very thoroughly, and any irritation caused by them must be allowed to subside completely before the joint is again disturbed. If the irritation run very high, and last long, and if, on each successive occasion, it become more decided, the forearm must be bent at a right angle with the arm, in semipronation, in order to give the greatest use of the hand in case the stiffening becomes permanent.

Fractures of the Elbow.—A few words may be said here in regard to these injuries, which comprise all those in which not only the lower end of the humerus, but one or both of the other bones entering into the joint are involved. They may be either simple or compound, and the extent of the lesion, whether of the bones or of the soft parts, may vary greatly. Sometimes the fragments are very much displaced, while, in other cases, they may remain almost undisturbed. Generally the cause is great direct violence, such as the passage of a wheel over the arm, or other crushing force.

When these fractures are compound, the position and extent of the wound of the skin will be influenced in some degree by the character of the cause. If the latter be direct violence, the wound may be at the back of the elbow; but if indirect, the skin being, as it were, burst open by the projection of the bone, the anterior surface of the arm just above the flexure is most frequently involved. In the former case, also, the wound is apt to be smaller than in the latter; although this, of course, is by no means a constant rule. Sometimes, although the fracture is compound, the joint is not laid open to the air, and this fact lessens the gravity of the injury.

Fractures of the elbow may occur to either sex, at any time of life; but, for obvious reasons, adult males are most exposed to the causes of such injury.

The *diagnosis* is sometimes quite clear as to the nature of the hurt, but it may not be easy to determine exactly which bones are involved, and to what extent. Malgaigne mentions a case, as follows: "In the only example of comminuted fracture of the elbow which I have seen, the humerus was intact, except that its articular cartilage was stripped off; the patient had fallen from a second story upon the elbow, and the wound answered merely to a transverse fracture of the olecranon, leading me to think that this process alone was involved. The patient dying on the fifty-eighth day, the autopsy revealed a comminuted fracture of the coronoid process of the ulna, as well as of the head and neck of the radius."

When the external wound is large, exploration with the finger may afford much more exact information as to the precise nature of the damage to the bones.

There are very few injuries in which the *prognosis* is more doubtful than in those now under consideration. Every pathological cabinet contains specimens illustrating most extensive fractures involving the elbow, from which recovery has taken place, with deformity indeed, yet apparently with a fair degree of usefulness of the limb. In Malgaigne's case, just mentioned, there was an incessant oozing of blood from the fractured surfaces, which filled the joint, and doubtless had to do with the unfavorable result; such a complication might occur in any case, and disappoint hopes otherwise well founded. On the other hand, Sir A. Cooper[1] relates the case of a brewer's servant, in whom the elbow was crushed by the wheel of a dray, so that the finger could be passed through the joint, and the artery thus felt. He refused to submit to amputation, and recovered, with sufficient motion in the elbow to allow him to resume his former occupation. Another case is given by the same author, in which a man, aged seventy-four years, with very extensive fracture, made a complete recovery; "although the form of the joint was irregular, yet a considerable degree of motion was preserved."

I think it may be assumed that, in the latter case, the joint was not laid open—a circumstance which, as a general rule, renders the chance of a good result much greater. When this can be ascertained, the surgeon may, therefore, venture to give the patient much more encouragement than if the latter is likely to undergo the risk of a suppurative arthritis.

When the joint does not show any sign of stiffening, and especially if passive motion neither gives pain nor excites inflammation, the prospect is favorable, even if the outward shape of the part is disfigured—the result of several displacements being to give something like the natural mechanism. Much, however, depends upon the judgment with which passive motion is employed.

For the *treatment* of cases varying so widely in the degree and character of the lesions presented, it can scarcely be expected that definite rules should be laid down. When the fracture is a simple one, the course to be pursued is identical with that recommended when only one of the bones entering into the joint is concerned.

In compound fractures, if the joint be not laid open, the fragments must be adjusted, and any that are entirely loose removed; the wound is next to be closed as securely as possible, and the limb placed upon a rectangular splint; inflammation is to be expected, and must be met by fomentations, evaporating and anodyne lotions, or irrigation. Upon its subsidence, the same treatment should be instituted as for simple fractures, provision being made for the dressing of the wound until it has completely healed.

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[1] Op. cit., p. 477.

When the joint is extensively laid open, or if the bones are very badly crushed, it may be good practice to excise the whole joint; a procedure which, although not mentioned by Malgaigne, has been resorted to with success in many instances, and is at present of recognized value. Sir A. Cooper cites two cases in which it was employed with excellent results by McIntyre, in one as early as 1829. I myself had at the Episcopal Hospital, a few years ago, a young man, who, by a fall from a roof, had sustained a very extensive compound fracture of the elbow; I freely excised the joint, and he recovered with so good an arm that he was able to resume his business as a tin-roofer.

When excision is decided upon, it is important to remember that much depends upon the removal of a sufficient amount of bone to leave the forearm freely movable; upon sparing muscular attachments as much as possible; and upon avoiding interference with vessels and nerve-trunks. Partial excisions have, in some instances, been done with success; but I think that the general result of experience is, that it is better to remove all the articulating surfaces, that healing thus takes place more quickly, and that to leave any portion of the joint adds nothing either to the safety of the procedure or to the subsequent usefulness of the limb.

Occasionally, besides the damage to the bones, the vessels are torn across, or such extreme injury has been inflicted on the soft parts as to be irreparable, and amputation must then be performed.

The question may be raised with regard to either amputation or excision, whether the better plan is to operate at once, or to wait until suppuration has been established; in other words, whether a primary or a secondary operation affords the best chance of a good result. I think it should be decided, not abstractly, but according to the circumstances of each case. If it is clear that operative interference must be resorted to, and the patient's condition does not forbid, there would seem to be no valid reason for postponing it. But if there is a doubt in the surgeon's mind, either as to the necessity of any operation, or as to which he should adopt, or if grave constitutional symptoms are present, a few days' delay may be of momentous advantage. Such questions, however, belong rather to general surgery than to the special branch now under consideration.

FRACTURES OF THE SHAFT OF THE ULNA are rare as the result of indirect violence, although Bellamy[1] has reported one in the upper third of the bone from a fall on the hand, in a child six years of age. Voisin is quoted by Malgaigne as having seen "a detachment of a longitudinal splinter from the articular facet" at the lower end, produced in the same way. Macleod has reported[2] a case seen by him in which the patient, in striking a blow, sustained a fracture of the styloid process of the ulna, with separation of the triangular cartilage. A more frequent cause is direct violence, as when a pugilist wards off a blow, and receives it on the edge of the forearm; or from a fall, striking the same part against a step or other resisting body. The ulna is subcutaneous in its whole length, and hence is specially exposed to injuries of the kind just referred to.

Labatt[3] saw a healthy girl who had sustained a fracture of the lower third of the ulna by muscular action, as she was engaged in wringing clothes. A previous injury had impaired the power of supination.

In the statistics from the Children's Hospital, already quoted, in the 316 cases, the ulna by itself is said to have been fractured 11 times, or in very nearly 3½ per cent. Yet the causes are much more prevalent among grown persons, and particularly in men, who, according to Malgaigne, contribute four-fifths of the subjects of this injury. Of the different portions of the bone, it would seem from the statistics given by Hamilton, as well as from those of Agnew, that the middle third is somewhat more frequently affected than either the upper or the lower; and the reason of this may be readily perceived.

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[1] British Medical Journal, Sept. 16, 1876.
[2] Edinburgh Medical Journal, Nov. 1874.
[3] Dublin Med. Press, April 8, 1840.

In the Museum of the Pennsylvania Hospital there is a specimen[1] of double fracture of the ulna, the forearm having been bent around a revolving shaft. "The upper fracture is near the junction of the upper and middle thirds, and is somewhat oblique. The lower fracture is in the lower third, and is transverse. At the time of removal the fractures were not complete, the fibres of the bone which remained unbroken being much bent." The patient was a boy aged fifteen.

When the ulna is broken by direct violence, the fracturing force will obviously tend almost invariably to drive one or both of the fragments toward the radius, and thus to diminish the interosseous space. The upper fragment, from the nature of its connection with the humerus, is not as movable, laterally, as the lower, which is moreover acted upon, in some degree at least, by the pronator quadratus muscle. But the upper fragment may be tilted either forward or backward, as indeed the lower may be also; and thus will result a deformity and change of relation between the bones, by which, if uncorrected, the pronation and supination of the hand would be almost altogether prevented. For the production of this unfortunate effect, it is not necessary that either fragment should be very markedly displaced; a very slight change of angle is sufficient to destroy the parallelism of the two bones, and thus to impair the efficiency of their mechanism.

Hamilton says that there is no other long bone the fractures of which are so often complicated as are those of the ulna; and Agnew makes nearly the same statement. The former author saw, in 12 cases out of 36, the radius dislocated forward, or forward and outward, and in one a backward luxation of both radius and ulna, while in four cases the fracture was compound. The rationale of the displacement of the head of the radius, after the support of the sound ulna is lost, is not difficult to comprehend.

A curious specimen exists in the Warren Museum,[2] which has been already noticed on account of the lesion of the radius; that of the ulna is thus described: "The fracture of the shaft of the ulna is very oblique, commencing at the depression of the articular surface, marking the separation of the coronoid process and the olecranon, extending almost longitudinally 3¼ inches downward, and detaching from the shaft that portion of the bone to which the olecranon was attached." A somewhat similar case, but extending downward only two inches, and followed by non-union, was reported by Brainard.[3] Very generally the fractures of the ulna present but a slight degree of obliquity.

The *symptoms* are pain and loss of power in the forearm and hand, swelling, ecchymosis, and tenderness at the seat of fracture. Sometimes the fingers of the surgeon, passed along the edge of the forearm, perceive a depression or angle, and crepitus is elicited on pressure. Occasionally, in order to develop this latter sign, it is necessary to grasp the upper and lower portions of the forearm, and make a slight effort as if to rotate the lower upon the upper. Care must be taken, however, to avoid any manipulation which might cause displacement, or increase it if it already exists.

The *diagnosis* is not often difficult, the subcutaneous position of the bone giving a fair opportunity for its thorough examination. The possibility of complications should not be lost sight of; the surgeon should see, for example, that the head of the radius is in its proper place.

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[1] Catalogue, p. 23, No. 1095.

[2] Catalogue, p. 173, No. 1031.

[3] Transactions of the Am. Med. Association, vol. vii. 1854.

Union generally takes place readily, but a number of cases of false joint have been observed in this bone, perhaps on account of rotary motion communicated to the lower fragment through too great liberty allowed to the hand, or it may be by the entanglement of a torn edge of the interosseous membrane between the fragments.

Callender[1] has recorded a case in which the styloid process of the ulna, carrying with it the triangular ligament (?), was torn off, and in which, when the parts were examined, the ulnar nerve was found wedged between the two portions of bone.

The *treatment* may be a very simple matter, or may present considerable difficulties. The first point is to correct any displacement that may exist; and the only direction that can be given for this is, that such manipulation is to be employed as may in each case be found most effectual. Sometimes the bone is brought into perfect line by merely pressing the soft parts into the interosseous spaces, anteriorly and posteriorly; and this should always be done, although it may also be requisite to correct an angle forward or backward, as well as to make some extension in order to disengage the fragments from one another, or from the torn interosseous ligament.

As a general rule, the semi-prone position (with the thumb upward), is the best; and if the patient is either a child or a restless or unruly adult, a splint extending from the middle of the upper arm to the ends of the fingers, with a right angle corresponding with the elbow, will serve to secure it. My own preference is for two small slips of wood, well-padded, and applied along the dorsal and palmar surfaces of the forearm, with very careful bandaging from the tips of the fingers to the elbow; a piece of binder's board, cut so as to form an internal, angular splint, reaching down to the ends of the fingers, and with the forearm part broad, so that its lower edge can be turned up to support the whole ulnar side of the limb, may then be softened in hot water, moulded to the arm, and secured by a roller. For the first few days the condition of the fingers should be carefully watched, lest the circulation be interfered with by the compression; a number of cases are on record in which neglect in this respect has cost the patients the loss of their arms, and even of their lives.

Some surgeons are content with a mere trough, in which the semi-prone forearm is laid, and confined by means of a bandage; but there can be no question that more efficient confinement is needed in many cases, and is safer in all.

In *compound fractures of the ulna* the treatment must be essentially the same, although a gap should be left opposite the wound to allow of its being dressed.

When the trough or angular splint is properly applied, the sling can hardly do any harm by pressing one or both fragments toward the radius; but it is better to have it of ample width. The hand should never be allowed to hang free, but should be well supported by the angular splint. When the apparatus is removed for the purpose of examining the limb, the utmost care should be taken to guard against any sudden displacement. I think it may even be better to leave the small splints in place for a week or two, and merely to ascertain by passing the fingers along the bone that the fragments are in their proper relation.

Passive motion is in these cases wholly unnecessary, and would be very likely to do harm. At the end of about four weeks, the arm-part of the supporting splint may be left off, and in a week more the hand may be set at liberty; next the small splints may be removed, and then the apparatus may be permitted to become loose, and so worn for a few days, when it may be finally dispensed with.

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[1] St. Bartholomew's Hospital Reports, 1870.

Pseudarthrosis, when it occurs in the ulna, is not easy to deal with on account of the presence of the radius. Of sixteen cases collected by Muhlenberg,[1] five were treated successfully by drilling, and in one the plan failed; four by resection, with one success, two failures, and the result in one not stated; three by frictions, with two successes and one failure; one successfully by tincture of iodine applied to the skin; another by scraping the periosteum subcutaneously; and another by mere mechanical pressure. From this it would appear that the methods which do not involve much disturbance of the parts are, in the case of this bone, the most effective.

I may add that Le Fort[2] has recently recorded a case in which he succeeded in obtaining union by means of electricity.

Malgaigne quotes from Bérard a case of comminuted fracture of the lower fourth of the ulna, with division, not only of the muscles, but of the ulnar artery and nerve; he tied both ends of the artery, dressed the wound, placed the forearm first upon cushions and afterward in the ordinary apparatus for fracture of both bones, and succeeded in obtaining, at the end of sixty-eight days, complete consolidation and cicatrization.

FRACTURES OF THE RADIUS alone constitute a very large proportion of the whole number of fractures, not only of the upper extremity, but of the skeleton in general. But this is due to the frequency with which the bone gives way at its lower part, close to the wrist; the other portions of it are much more rarely broken. In illustration of this statement, I may quote the figures given by Agnew,[3] derived from the registers of the Pennsylvania Hospital. Out of 648 fully recorded cases, 24, nearly 4 per cent., were in the upper third of the bone; 53, a little over 8 per cent., in the middle third; and 571, about 88 per cent., in the lower. Hamilton's observations present a curious agreement with these; out of 101 cases, 3 were in the upper third of the bone, 6 in the middle third, and 92 in the lower.

Fractures in the *upper third* of the bone are generally, I think, the result of direct violence. But in 1856 I saw a case under the care of Dr. Miltonberger, in Baltimore, in which the radius had given way very high up as the patient was pulling very hard in driving a pair of horses. I do not know of any other recorded case of the kind, but the history of this one was clear, and the mechanism may be easily perceived; the twist impressed upon the bone by the action of the biceps was such as to overcome the strength of the tissue.

Fracture of the *neck of the radius*, properly so called, may take place from direct violence, as in some cases of crushing of the elbow; although I think this bone is more apt to escape by reason of its mobility and small size. But no instance is known to me in which it has been ascertained to be broken by itself. The specimen in the Mütter Museum, which has been sometimes said to illustrate this lesion, is, in fact, one of fracture through the tubercle, and the displacement is such as to show the action of the biceps upon the upper as well as upon the lower fragment; it is without history, which is much to be regretted. Moore[4] has reported a case in which the separation was clearly high up in the shaft, and not in the neck itself; and he refers to another, observed by Parker, where there was luxation of the head of the bone, which

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[1] Agnew, op. cit., vol. i. pp. 768, 769, 770, 806.

[2] Bull. et Mém. de la Société de Chirurgie de Paris, 1882.

[3] Op. cit. vol. i. p. 901.

[4] London Med. Gazette, Oct. 17, 1845.

"was drawn considerably above the elbow-joint, by the contraction of the biceps muscle;" reduction was accomplished, and the case is said to have done well.

In speaking of the relative frequency of fractures in different portions of the radius, it will be remembered that I quoted statistics from Agnew and Hamilton, in which the bone was considered as divided into an upper, middle, and lower third. I venture to suggest that it would be better for practical purposes to study these injuries according as they affect the shaft of the bone above or below the insertion of the pronator teres, leaving fractures at or close to its lower extremity in a separate class. For there is no portion of the skeleton in the fractures of which the influence of muscular action upon the production or maintenance of displacement is more distinctly traceable than it is in those of the shaft of the radius.

The great function of this bone is pronation and supination, as may be clearly seen by a glance at the muscles which act upon it. One of these, the biceps, is indeed a flexor, but it is a supinator also. The supinator brevis acts upon the upper portion—almost, if not quite, half of the bone—the supinator longus upon its lower end. The pronator teres is inserted into about an inch of its outer edge at its mid-length, while the pronator quadratus acts in a supplementary way on the lower portion of the shaft.

If now the shaft gives way between the tubercle and the insertion of the pronator teres, it must be obvious that while this muscle will tend to rotate the lower fragment into pronation, and to drag it toward the ulna, the upper fragment will be rolled outward by the supinator brevis and biceps, the latter also tilting it up forward. The action of the supinator longus in opposition to the pronator teres will amount to nothing as soon as the continuity of the bone is lost; and the pronator quadratus will simply, by the contraction of its upper fibres, pull the lower fragment toward the ulna.

If, on the other hand, the shaft is broken below the insertion of the pronator teres, this muscle will draw the upper fragment toward the ulna, but its rotating action will be opposed by the supinator brevis and biceps; the pronator quadratus will act in the same manner as before, but more strongly, as the fragment will be shorter. Here the displacement produced will be an angle salient toward the ulna, while in the former case there will be added a rotation outward, as well as a tilting up forward, of the upper fragment. Clinical observation, as well as the testimony of museum specimens, will be found to support these statements, the practical bearing of which will presently further appear.

Malgaigne gives some curious facts as to the distribution of these fractures between the sexes. He found the radius broken in ninety-five males, and in sixty-five females;[1] but this proportion, three to two, was not maintained at all ages.

> "The number of male cases to females is ten to one in infancy; between fifteen and twenty it is fifteen to one. Thus up to twenty years of age this fracture is almost exclusively masculine. From twenty to forty-five, it affects women in pretty large numbers; twenty-two, in a total of seventy-two. But, after forty-five, another change occurs, and the fracture displays a marked preference for the female sex; there being but twenty men to forty-one women."

As to the *causes* of these fractures, they would seem to be sometimes direct violence, sometimes falls on the hand. Malgaigne quotes from Van Niérop the case of a woman, aged thirty, who, after wringing out two large sheets, felt sharp pain in the forearm, when a fracture in the lower third of the radius was detected. O'Brien[1] reports that he saw an oblique fracture of the bone, about three inches above the wrist, produced by muscular effort in aiding to lift a large cask. It is not improbable that cases of this kind are more frequent than would be supposed from the scantiness of the records.

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[1] These figures include all fractures of the radius—not those of the shaft of the bone only, but those of its lower extremity also.

Prominent among the *symptoms* of fracture of the shaft of the radius is always loss of power in the hand; although the patient may still be able to flex the fingers, and perhaps to pull or lift in some degree. But from what was before said as to the function of the radius, and the action of muscles upon it, it must be clear that the breaking of this bone cannot fail to render the hand useless, for want of pronation and supination. Deformity is usually present, the forearm having a curiously twisted look; and if the hand is grasped and rotated, there is an odd sense of looseness in the limb, the patient experiences pain, and, unless the fragments are separated altogether, there is crepitus. I have never myself seen a case in which the latter symptom was wanting. The injured part quickly swells, and the other phenomena become much obscured.

In examining a forearm for the detection of this or any other fracture, the best procedure is for the surgeon, after noting the position in which the limb lies, to grasp the hand with his corresponding hand, and bring it into semi-pronation; then to run the fingers of his other hand along the ulna, with some pressure, so as to determine the soundness of that bone. Next, applying his disengaged hand gently but closely to the upper part of the forearm, he rotates the patient's hand, with slight extension; the fragments will usually be felt to rotate upon one another, and at one point the movement will cause pain. Greater certainty is given to this manœuvre, if the thumb of the surgeon is applied to the head of the radius, which may often be felt not to follow the motion of the hand as it normally should. The precise point of fracture may be determined by passing one or two fingers lightly but firmly along the bone; a certain yielding, with crepitus, will be felt when the spot is reached, and the patient will experience pain. When the fracture is below the mid-point of the bone, it can be much more readily perceived than above, where the examination must be made through a greater or less thickness of muscular tissue.

When the symptoms are ordinarily distinct, there can be little or no difficulty in the *diagnosis;* but it may readily be imagined that if the periosteum should be untorn, and the fragments be thus held in contact, the fact of fracture might escape detection. Serious displacement would not under such circumstances be likely to ensue; and especially if, notwithstanding the absence of conclusive symptoms, the case were treated as one of fracture.

I may mention that the rotation of the radius in an uninjured arm sometimes gives rise to a sound somewhat resembling crepitus, either by contact of the head of the bone with the condyle of the humerus, or by friction of the tendons in their sheaths. Any error thus induced would, however, be on the safe side.

From what has already been said, it will be perceived that the result of fracture of the shaft of the radius, if left to itself, would be likely to be the loss of much of the usefulness of the hand. If the bone were broken above the insertion of the pronator teres, the upper fragment would be supinated, and the lower pronated; the upper would be tilted forward, and the lower drawn inward toward the ulna. If the fracture were below that point, the upper fragment might be but little rotated, but the lower would be drawn away from it, and from its shortness even more strongly pulled toward the ulna. And in either case the displacement of the upper end of the lower fragment would be favored at least by the action of the supinator longus muscle; of this a striking illustration is given by Malgaigne.[1] He says, "the styloid process has been drawn up to the level of that of the ulna, than which it is notably lower in the normal state of things." How this was done, he does not say; but it seems to me to be best explained by the action of the supinator longus.

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[1] Atlanta Med. Register, 1881.

In *treating* these injuries, two objects are to be especially aimed at: to place and keep the fragments in their normal relation as to their axes, and to maintain the inter-osseous space. Lonsdale, long ago, urged the importance of the former point, but I think that some later writers have in great measure lost sight of his views, and have given attention too exclusively to keeping the two bones apart.

Perhaps it is not making too sweeping a statement to say, that in all fractures above the middle of the bone the forearm should be supinated, while in all below that point the semiprone posture is preferable. For in the former case we want, to use Lonsdale's words, "to place the hand and forearm in such a position, that the lower portion of the bone may be supinated to the same extent as the upper;" but in the latter the condition of supination of the upper fragment does not exist.

In any fracture of the radius, then, above the insertion of the pronator teres, I should advise the use of an anterior angular splint of wood, carefully padded; and on the dorsal (in this case the lower) surface of the forearm I should place a narrow slip of wood, padded so as to act as a compress to fill up and maintain the interosseous space. The angle of the splint may be about 90°, or a little less if the upper fragment of the bone tends to be strongly tilted up. If the action of the supinator longus muscle, drawing the styloid process of the radius upward, toward the elbow, be very marked, it may be well to apply slight but steady extension of the hand toward the ulnar side; means of doing this will readily suggest themselves. The best plan in my opinion would be to put on the hand a glove, with the fingers removed, and with tapes sewed to it by means of which it could be tied to the corner of the splint; or they could be brought up over a notch at that point, to be fastened on the upper surface of the board. To make this dressing effective, the lower part of the forearm, just above the wrist, must be steadied on the ulnar side; which may be done by means of a wide loop of adhesive plaster, both ends of which may be brought to the outside of the splint, on its upper or palmar surface, and there fastened.

When the radius is broken below the insertion of the pronator teres, the best appliance is an internal angular splint reaching from the upper part of the arm to the ends of the fingers, and with the part corresponding to the hand so shaped as to draw the hand somewhat strongly downward, or toward the ulnar side. The forearm-part of this splint should be carefully and firmly padded along the middle, especially toward the wrist; and a similarly padded dorsal splint, but much narrower, should be laid along the back of the forearm.

Before applying the splints in any case, the fragments should be carefully restored to their normal relation, and so held until the dressing is complete. The bandaging should be done with the utmost care, snugly, but not tightly; and the surgeon will do well to remember that he is dealing with a part in which gangrene has repeatedly been induced by neglect or want of skill in applying apparatus. Frequent inspections should be made, and the state of the circulation in the fingers watched; upon the slightest appearance of congestion, or complaint of undue pressure, the limb should be stripped and the dressing reapplied, with such modification as may seem to be demanded.

Within three or four days it may be expected that the swelling will subside, and that the bandages will become inefficient; but in removing them care should be taken not to allow of any displacement of the broken bone.

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[1] Atlas, Pl. IX. Fig. 5. Translation, Fig. 50.

Compound fractures of the radius in its shaft may of course occur; but I do not remember to have ever seen one, except from gunshot wound, and there are no special points which require comment in regard to the phenomena or treatment of such a case.

FRACTURES OF THE LOWER PORTION OF THE RADIUS are among the most common of accidents, and must always have been so; yet it was not until the present century that they were distinctly recognized and accurately described. The history of the development of our present knowledge of these injuries is so curious us to merit some notice.

Pouteau[1] had thrown out the idea that fractures of the radius in the vicinity of the wrist, caused by falls on the hand, were "generally mistaken for sprains, for incomplete luxations, or for separations between the ulna and radius;" but the statement seems to have attracted no attention at the time. The same view was promulgated by Desault;[2] but to Colles,[3] of Dublin, is due the credit of having given the first clear and practical account of these injuries and of their distinctive features. Dupuytren,[4] Goyrand,[5] Diday,[6] and Voillemier,[7] realized the importance of the fracture in question, although none of them seem to have been aware of Colles's paper; and the same may be said of Nélaton and Malgaigne. Even Sir Astley Cooper makes no mention of Colles's name, and Fergusson barely alludes to his having written on the subject. In fact, this first real investigator of the matter would seem to have been forgotten until Prof. R. W. Smith of Dublin, in his very valuable work,[8] accorded him the credit to which he was so justly entitled. At present, the name "Colles's fracture" is generally recognized by surgical writers, and employed to designate fractures of the radius close to the wrist, even if not corresponding exactly to the description which Colles gave. Prof. Gordon, of Belfast, has published[9] some researches which have shed further light upon the mechanism of these fractures, as well as upon their treatment; his views have found confirmation in some interesting cases recorded by Cameron, of Glasgow.[10]

In the United States, attention was first drawn to the subject by Dr. John Rhea Barton,[11] of Philadelphia; his views were based upon clinical observation only, and not upon anatomical facts, yet they were ingenious and well stated, and found extensive acceptance among the surgeons of this country.

After this, no separate original American paper on this topic appeared for over thirty years, until Prof. Moore,[12] of Rochester, advanced the opinion that the fracture of the radius was a less important lesion than the luxation of the lower end of the ulna, which certainly is often a marked feature of these cases, and suggested a plan of treatment based upon this view.

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[1] Œuvres Posthumes, tome ii. p. 251. Paris, 1783.

[2] Œuvres Chirurgicales, tome i. p. 155. Paris, 1813.

[3] Edinburgh Med. and Surg. Journal, April, 1814.

[4] Leçons Orales, tome iv. p. 161. Paris, 1834. See also the volume "On the Injuries and Diseases of Bones" (Sydenham Society, 1847), which consists of selections from the above-named work.

[5] Gazette Médicale, 1832, and Journal Hebdomadaire, 1836.

[6] Arch. Gén. de Médecine, 1837.

Ibid. 1842; article republished in his Clinique Chirurgicale, Paris, 1862.

[8] A Treatise on Fractures in the Vicinity of Joints, etc. Dublin and New York, 1854. (The preface to this work is dated 1847.)

[9] A Treatise on Fractures of the Lower End of the Radius, etc. London, 1875.

[10] Glasgow Med. Journal, March, 1878.

[11] Med. Examiner, 1838.

[12] Transactions of the Med. Society of the State of New York, 1870.

Another essay which has attracted much attention, and which has shed additional light upon the mechanism and pathology of these lesions, has been published by Pilcher,[1] of Brooklyn. I may perhaps mention also a paper of my own, read before the surgical section of the American Medical Association, in 1878,[2] the views contained in which will be presented, together with those of the authors previously named, in the following pages.[3]

The brief sketch now given is that of a very great and important change in professional opinion. Luxations of the wrist, which were formerly supposed to be of very common occurrence, and described in detail, in at least four varieties, have been relegated to a place among the rarest lesions; while fractures of the lower portion of the radius are recognized as of extreme frequency.

A careful study of the shape of the bone will render the study of its fractures much easier. In speaking of it, it will be supposed that the hand is hanging by the side, with the palm looking forward, so that the anterior surface is the palmar and the posterior the dorsal, that the inner edge is the ulnar, and that the carpal articulating surface is downward. Adduction is bending the wrist so as to bring the hand toward the median line, or the side of the little finger, abduction bringing it toward the outer or thumb-side; in the former case, the angle on the ulnar side, between the hand and forearm, and in the latter, that on the radial side, is rendered more acute. Points to be noted are the projection of the radial styloid process, and the fact that it is normally at a lower level than that of the ulna; the sudden swell of the bone downward, just above the joint, so that there is an enlarged portion, as compared with the shaft, somewhat irregularly cubical in shape; and the forward curve of the anterior wall of the bone, making a decided concavity in its outline if looked at from either side. This conformation is sometimes more and sometimes less marked. The fact that the most frequent *cause* of fracture of the radius, low down, is falling on the palm of the hand, may readily be seen to explain its comparative infrequency in childhood, as the weight is smaller and the leverage less than in similar accidents in the adult. In youth, epiphyseal separations, although not often met with, are not unknown; and at all later periods of life the bone gives way with great readiness.

Both sexes are alike liable to these injuries.

As already said, in a vast majority of the cases the cause is a fall on the palm of the hand; in a few, however, the back of the hand comes to the ground, and the difference in the effect produced is of no small importance, as I shall try to show hereafter. Direct violence is, I think, still more rarely assignable as a cause; Malgaigne quotes one case from Hublier, in which a young girl, whose wrist had been caught between a carriage-pole and a wall, had a transverse fracture of the lower part of the radius, the lower fragment being also split vertically into two parts.

Authors have expressed very divergent views as to the lines of these fractures. Without quoting these at length, I may merely say that the practical result of the examination of cases and specimens seems to me to be that the lines of breakage are almost infinitely various. Sometimes the bone gives way almost exactly transversely, the fragments being, however, serrated or notched; sometimes the fracture is oblique from before backward, or from within outward, or part of it may run in one direction and part in another. Sometimes the separation takes place very close to the joint, sometimes farther from it.

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[1] Transactions of the Med. Society of the County of Kings, March, 1878.

[2] Published in the Am. Journal of the Med. Sciences, Jan. 1879.

[3] The reader will of course understand that the above list is not intended to embrace all that has been written on the subject, which has been of course dealt with in systematic works, as well as in short articles containing reports of cases, suggestions in regard to treatment, etc.

Sometimes the lower fragment is split or fissured in various directions, so as to constitute two or more fragments of very irregular size and shape. Occasionally the fracture begins at the articular surface, and runs up into the substance of the bone to a greater or less distance; of this a notable example exists in the Warren Museum,[1] and another is mentioned by Dupuytren.[2] In another specimen[3] in the Warren Museum, there is a double fracture, the result of direct violence; it is described as "comminuted fracture of the lower end of the radius, just above, and into the joint, and a second fracture, two and a half inches above the joint." Dupuytren[4] records another case, in which a woman, aged sixty-two, having rolled down about sixty steps, had "one fracture about an inch above the joint, and the other an inch and a half higher up. The ulna, which was dislocated inward, protruded to the extent of more than an inch through the skin."[5] The Museum of the New York Hospital contains a specimen[6] described as a fracture of the lower end of the radius "obliquely upward and backward, from within a quarter of an inch of the palmar edge of the carpal joint. The fracture was transverse and incomplete; for a long narrow fragment passing up from the styloid process was still continuous with the shaft. This connecting bony bridge was slightly bent so as to permit the articular surface of the radius to be slightly rotated toward the dorsal surface of the forearm." In the other forearm there was extensive comminution of the radius for the space of two inches, and the shaft "is seen to be invaded by a longitudinal fissure running up from the fractured surface."

Occasionally there is a separation of a lateral portion of the articular extremity. A number of instances are on record in which the styloid process has been thus broken off. Such a specimen exists in the Wistar and Horner Museum, and another in the Warren Museum;[7] Callender[8] speaks of two in museums in London, and Hamilton thinks that he has made out the lesion twice in the living subject. One curious case is recorded by Butler,[9] in which a boy of fourteen, by a fall from a height of thirty feet, had the styloid process broken off and drawn upward an inch and a half, where it became firmly united.

In the New York Hospital Museum there is a specimen[10] in which "the only fracture of the radius consists in a chipping off of a small portion of the lower extremity, so as to separate the articular facet for the ulna from the rest of the bone. One of the carpal bones is also broken." It is difficult to entertain any other theory of the mechanism of this lesion than that of direct violence.

Gross[11] records the following: "In the case of a young man whom I attended along with Dr. Chenowith, the lower extremity of the radius was split in two by a transverse and an oblique fissure, the larger fragment being completely detached and thrown inward and forward over the ulna, whence, as it was impossible to replace it, I removed it by incision. A good recovery took place, with hardly any impairment of the functions of the wrist-joint."

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[1] Catalogue, p. 174, No. 1035.

[2] Injuries and Diseases of Bones, p. 126.

[3] Catalogue, p. 174, No. 1038.

[4] Op. cit., p. 127.

[5] I am tempted to refer here to an instance reported by Mr. Godlee (Med. Times and Gazette, 1883), in which a man, aged twenty, by a fall backward on his hands, sustained a compound fracture of the left radius at the junction of the middle and lower thirds, with displacement forward of the lower end of the ulna, which projected beneath the skin. "An incision was made, and the tendon of the flexor carpi ulnaris, which had slipped behind the bone, was raised up with a blunt hook; but the ulna could not be replaced until first the styloid process and then the end of the bone had been sawed off." The mechanism of this injury seems to me to have been clearly the same as that in Dupuytren's case above mentioned, in which the removal of the end of the ulna was also practised, but not with so complete a restoration of the functions of the limb.

[6] Catalogue, p. 80, No. 130.

[7] No. 4631. (Mentioned in a letter from Dr. Hodges.)

[8] St. Bartholomew's Hospital Reports, 1865.

[9] New York Medical Journal, 1867.

[10] Catalogue, p. 79, No. 128.

[11] Op. cit., vol. i. p. 970.

From what has been said, it is evident that the widest variety has been observed in the lines of breakage in the neighborhood of the wrist. Yet it is none the less true that in the vast majority of cases the lower end of the radius is fractured in a direction more or less transverse, and that the deformity produced is nearly the same in all.

Mention has already been made of the fracture theoretically described by Barton; and as his paper, the first one published on this special subject in America, had for a time a good deal of influence on professional opinion, it may be well to explain briefly what his views were. He says that in the act of falling "the hand is instinctively thrown out, and the force of the fall is first met by the palm of the hand, which is violently bent backward until the bones of the wrist are driven against the dorsal edge of the articulating surface of the radius, which, being unable to resist, gives way. A fragment is thus broken off from the margin of the articular surface of this bone, and is carried up before the carpal bones and rested upon the dorsal surface of the radius; they having been forced from their position either by the violence or by the contraction of the muscles alone." Again, he says: "It sometimes happens, also, though rarely, that fracture of a similar character to the one first described occurs *on the palmar side* of the radius, from the application of force against the back of the hand while it is bent forward to its ultimate degree."

In the forty-five years which have elapsed since the publication of these views, there has not been, as far as I have been able to ascertain, a single instance placed on record in which they have been confirmed by dissection. Voillemier[1] quotes one case from Lenoir, which may have been of this character, but is open to doubt; and in most cases of comminution of the lower fragment, the dorsal portion has been broken off. But although a detached piece might be carried up before the carpal bones, there would not be, as he says, " on the palmar side a prominence which is round and smooth, and differing in this from similar projections formed by the fractured ends of bones." Nor is it likely that, from a fracture merely of the posterior lip of the articulating surface of the radius, treated with ordinary skill or care, such bad results would often ensue as Barton enumerates: "A crooked arm, deformities, rigid joints, inflexible fingers, loss of the pronating and supinating motions." Yet consequences like these are frequently seen to follow the fractures just above the wrist.

Fractures presenting such various conditions must, of course, be due to equally various mechanisms. Nevertheless, the vast majority of cases must be ascribed, I think, to the "cross-breaking strain" produced by over-extension of the wrist, as maintained by Callender, Gordon, and Pilcher. In other words, the hand being forced backward, an immense tension is put upon the anterior carpal ligament, and thus a leverage is exerted upon the lower end of the bone, beyond the resisting power of its structure. First the palmar wall gives way, then the columns or lamellæ in succession, and finally, the dorsal wall.

When the fall takes place on the back of the hand, the bone gives way in like manner, but in a reverse direction; the mechanism is the same. That this occurs, I think there is ample evidence, although it has been doubted by some writers.

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[1] Archives Générales de Médecine, Déc. 1839.

Fractures of the lateral margins of the articulating surface are less easily explained, but may be due to the sudden force brought to bear by violent contact of the carpal bones, and the same may be said of the rare instances of "stellate cracks."

Upon the occurrence of transverse fracture in the way above stated, the area of the end of the upper fragment is less than that of the opposed surface of the lower; and the force continuing to act, the former is driven down into the cancellous tissue of the latter, and may split or burst it into several lesser fragments, thus comminuting it. Or, if this splitting does not take place, the compact wall may penetrate the spongy texture of the lower fragment, constituting an impaction. Experiments on the dead subject have been many times made by different observers, and always with the same general result, in support of the above statements.

With regard to the occurrence of impaction, writers have been greatly at variance. Gordon says that in Colles's fracture it is impossible. Callender says that thirty-six specimens in the various museums in London show deformity in all clearly due to "the impaction of the proximal into the distal end of the bone." Voillemier thought the impaction so marked a feature of the injury that he would rank it among what he calls "fractures by penetration." R. W. Smith argues that the appearances which led Voillemier to this opinion were due to deposits of new bone. This question seems to me to have been discussed at greater length and with more zeal than its importance really warrants. It cannot be settled upon the evidence of specimens of old and long-healed fractures alone, but lesions of recent date must be examined also; and from both together I think the conclusion is unavoidable that impaction occurs in some cases, while in others it is wanting. Deposits of new bone may undoubtedly take place in some cases, simulating impaction, or increasing its apparent extent.

Probably the experience of most surgeons will confirm the statement of Pilcher, that a fall on the palm of the hand may be productive of a mere strain of the ligamentous structures, of bruising or even of fissuring of the bone, or of actual fracture with separation, according to the grade of the force brought to bear in over-extension of the hand.

The *symptoms* of this fracture are, as a general rule, very decided. There is great pain, and instant helplessness of the hand; the wrist is almost always deformed in a marked degree, and often both preternatural mobility and crepitus are present. Swelling comes on very rapidly, and, in some cases, there is ecchymosis, although, by reason of the thickness of the skin of the palm, this is not as apt to occur as in fractures in most other regions.

The deformity requires special mention. It is such as might be expected from the bending backward of the lower extremity of the radius; the back of the wrist is humped up, and there is a corresponding depression at the palmar side, with a sort of creasing of the skin. Sometimes the dorsal prominence is distinctly greater at the radial side, the part having a twisted appearance. By Velpeau the deformity was said to resemble the back of a silver fork, and the comparison is not an inapt one. Taken together with the pain and loss of power in the hand, it is often in itself conclusive as to the nature of the injury.

Preternatural mobility may usually be detected by grasping the patient's hand (as if in shaking hands), and taking hold of the forearm; then flexing and extending the wrist. By the same manœuvre crepitus is apt to be elicited, but it may be very slight. In the case of decided impaction, both of these symptoms may be but slightly marked; when they are very readily perceived, there is reason to suspect comminution. Maisonneuve[1] records the following case: A woman, aged seventy, fell, striking the palm of her right hand. She had instantly great pain and tenderness of the wrist, and complete loss of power in the hand, which became swollen; but there was no deformity nor crepitus. If, however, the hand was strongly extended, there was perceptible a yielding of the radius about an inch above the joint. She died on the fourteenth day, and the diagnosis of fracture was verified; but the periosteum on the dorsal face of the bone was untorn. The styloid process of the ulna had been wrenched off, and was adherent to the internal lateral ligament.

Besides the "silver-fork" deformity, there is in these cases an abduction of the hand, so that its radial border forms with that of the forearm an entering angle, and the ulna projects strongly on the other side of the wrist. This is due largely to the fracturing force, the hand being stopped while the weight of the body continues to drive the upper fragment downward and forward, and thus to push it into the cancellous tissue of the lower. It is easy to see that in the majority of cases the impact comes chiefly upon the radial side of the palm, in falls upon the hand, and hence that the penetration of the lower by the upper fragment would naturally be greater on that side. But this is in fact a shortening of the forearm on this margin by a change in the position and plane of the lower articulating surface of the radius, and the angle of the hand with the forearm must be correspondingly changed. The ulna does not move; it cannot, by reason of its very close articulation with the humerus above. Hence, it seems to me incorrect to speak of luxation of the ulna as an element of this lesion; it is the hand which, with the lower fragment of the radius, assumes a new position with regard to that bone. And in strictness the ulna should not be said to project, although the expression may be retained as a matter of convenience.

Perhaps I may best speak here of the views of Prof. Moore, of Rochester, who maintains that "luxation of the ulna" is the key to the pathology and treatment of the lesion in these cases. It has been already stated that there is often a twisting of the wrist along with the mere over-extension which breaks the radius, and when the change of angle between the hand and forearm, just spoken of, takes place, there must of necessity be also a change in the relations between the carpal bones and the lower end of the ulna. And by entanglement in the annular ligament or a tendon (generally, I think, that of the extensor carpi ulnaris), the correction of this latter displacement may be rendered very difficult. Admitting, however, that such a state of things exists, as claimed by Prof. Moore, in one-half of the cases, it seems to me that its absence in the other half certainly makes it secondary to the lesion which is always present. With all deference to his learning and practical ability, I am myself unable to accept his theory, to which I believe the above statement does justice; of the treatment based upon it, which has some great merits, more will be said presently.

It has been already stated that swelling takes place very rapidly after fracture in this region. When the lesion involves the articular surface, or in other words enters the joint, there is copious effusion into this cavity, and active inflammation may be set up. And in any case the sheaths of the tendons are thus distended; besides which, although at a somewhat later stage, the subcutaneous areolar tissue becomes the seat of lymphization, and sometimes, especially in feeble or aged persons, of œdematous fulness.

Simultaneous fracture of both radii near their lower extremities has been observed in many instances, the reason of its frequency being obvious.

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[1] Clinique Chirurgicale, tome i. p. 164.

Nothing special need be said in regard to it, as each lesion is as independent of the other as if the limbs belonged to different bodies.

Compound fracture is very rare in this region; except in gunshot injuries, or in railroad or machinery accidents, indeed, I do not know that it is ever seen. The neighboring bones and soft parts would in such a case be likely to be also involved, and the sum of the injury would be great enough to demand amputation. In a number of instances recorded by Hamilton and others, the lower extremity of the ulna has been driven through the skin, having had the carpus torn away from it along with the distal fragment of the radius; but here the fracture is still a simple one, and the lesion just mentioned is a complication only.

Bryant[1] mentions a very curious complication, produced by a fall from a height, in a man aged thirty. "There was an impacted Colles's fracture of the right radius, and a vertical fracture of the head of the same bone into the joint." A much more common complication, especially apt to occur in cases due to direct violence, is fracture of one or more of the carpal bones, the scaphoid and semilunar being those oftenest affected.

Epiphyseal separations of the lower end of the radius have been spoken of by some authors;[2] but they do not present any special features as compared with ordinary fractures in this region.

When, as happens in a small proportion of the cases, the fracture is the result of a fall on the back of the hand, the distal fragment is driven forward, so that the articulating surface looks toward the palmar instead of toward the dorsal aspect of the limb. The leverage is then exerted in the direction of flexion, and not of extension, and the hand is bent forward, so that in the state of pronation it makes an angle downward with the forearm. Of this I have lately seen a striking instance, which will be further spoken of in connection with the subject of treatment.

In such cases the symptoms are very nearly the same as in those of the ordinary form of the injury before detailed; but there is a slight difference in the character of the deformity, such as will readily be understood. The lower fragment, instead of rising up on the dorsal surface, drops forward, and the "silver-fork" shape of the wrist is much less distinct.

The course of these cases is extremely variable. Unfortunately, an opportunity is not seldom presented of seeing the results of treatment so inefficient as to amount to almost nothing. Often the deformity is uncorrected, and the patient goes through life with the wrist misshapen. But as union takes place, and as the irritation in the sheaths of the tendons and in the neighboring soft parts subsides, the usefulness of the limb is restored, and the hand regains its strength, except for actions consisting in pushing, and such as require its complete flexion on the forearm.

When the force has acted on the back of the hand, it is extension that is apt to be thus interfered with, and the member acquires a claw-like appearance, aggravated in one case which has come under my notice by nerve-lesions, impairing the nutrition of the part, shrivelling the fingers, and totally abolishing strength and freedom of motion.

Under proper treatment, however, a far more favorable condition of things is brought about. Union generally takes place readily, and if the fragments have been put into proper apposition, the shape and strength of the wrist, as well as the motions of the part, are completely restored.

Between these two extremes—union with great deformity and union with perfect restoration of shape, there are of course innumerable gradations. In the majority of cases, the result obtained is a useful hand, with perhaps a degree of disfigurement not sufficient to be a serious annoyance, unless the patient be a woman in the higher walks of life. A city surgeon may almost daily see the most laborious occupations pursued by persons who have been the subjects of this fracture, as testified to by the unmistakable distortion of the affected limb—the projection of the ulna, the abduction of the hand, and the thickening of the wrist.

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[1] Manual for the Practice of Surgery, 2d Am. edition, p. 788.

[2] Holmes, Surgical Treatment of Children's Diseases, p. 254; R. W. Smith, op. cit., p. 165.

Anchylosis of the joint very seldom occurs; a fact which may be accounted for by the rarity of actual involvement of the articular surface. Even when there has been extreme distension of the tendinous sheaths, and the stiffening of the wrist is at first strongly marked, the parts ultimately resume their suppleness, except in the case of very old, feeble, or rheumatic subjects. Barometric pains are sometimes complained of subsequently, but not, I think, as often as after most other fractures.

The *diagnosis* of these fractures does not generally offer very much difficulty. Luxations of the wrist, with which they would be most likely to be confounded, are so rare as practically to be almost excluded from consideration. One case, observed by Lenoir, and published by Voillemier,[1] is undisputed, having been verified by dissection after the patient's death. Another, mentioned by Hamilton,[2] seems to me to be beyond doubt. Nearly fifty others have been recorded as such,[3] but none of them can be accepted upon the evidence offered. I have had one case in which the character of the deformity, the ease of complete reduction, and the speedy resumption of the normal condition and use of the hand, convinced me that there had been a luxation of the carpus backward; and two others which I had reason to believe were of that nature, but in regard to which I feel less positive.

Admitting that luxation can occur, it is of course desirable that the distinctive features of the two lesions should be known, so far as they can be from the limited facts at command.

The pain, helplessness of the hand, and deformity, are alike in both. But on examination, instead of the rough and irregular edges of the broken bone, the fingers of the surgeon will, in the case of a dislocation, find on one side the smooth concavity of the articulating ends of the bones of the forearm, and on the other the rounded convexity formed by those of the carpus. The styloid processes, according to Hamilton, were plainly felt in his case. Preternatural mobility, apt to be present in fracture, although perhaps in but slight degree, will be wanting in dislocation, and so also will crepitus. Reduction, often very difficult in fracture, gradually effected, and attended with a grating sound, is easy, sudden, and marked by a click or snap, in luxation.

The only other lesion with which fracture could be confounded is a severe sprain, and the limits between these injuries are, as already said, very ill defined. It seems quite possible that cases are not very rare in which the bone is partially broken through, and that sometimes, when the bone is completely divided, the fragments may remain in contact, the fibrous structures being untorn. A mistake, however, would, under such circumstances, be really a matter of no moment.

The *treatment* of fracture of the lower end of the radius has been very extensively discussed, and different surgeons have held widely different views as to the best means of accomplishing the indications, which in themselves are simple enough—to correct the malposition of the fragments, and to maintain them in accurate contact until union shall have occurred.

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[1] Archives Générales de Médecine, Déc. 1839; also in his Clinique Chirurgicale, p. 120. It may also be found in R. W. Smith's work before quoted.

[2] Practical Treatise on Fractures and Dislocations, p. 712.

[3] The reader who wishes to follow up the matter can find in Malgaigne (op. cit., tome ii. p. 681 *et seq.*), and in a valuable prize essay by Dr. T. K. Cruse, published in the Transactions of the Med. Society of the State of New York for 1874, the references to these reports. I am at a loss to account for the want of correspondence between the lists given by these two authors.

I do not know how to express strongly enough my conviction, that the great reason why deformity so often follows fractures of the radius close to the wrist, is because of failure to carry out the first of the above indications. *Reduction is not effected at all.* If this is once thoroughly accomplished, a good result can be obtained with almost any form of apparatus fitted to the case with ordinary skill and care. If it is not properly attended to, it makes no difference how elaborate may be the appliances used, the deformity will surely become permanent.

Authors have differed greatly as to the condition of such fractures with regard to reducibility. Callender said, that "in a great number of cases the impaction so fixes the fragments that they cannot be unlocked, and the deformity is permanent." Colles, on the other hand, said: "If the surgeon lock his hand in that of the patient and make extension, even with moderate force, he restores the limb to its natural form; but the distortion of the limb instantly returns on the extension being removed." Sir A. Cooper thought that powerful extension was required, but that the moment it was relaxed the deformity recurred. Moore holds that if the head of the ulna is disengaged from the annular ligament and tendon of the extensor carpi ulnaris, the whole difficulty is overcome. Pilcher regards the dorsal periosteum and the ligament between the cuneiform bone and the styloid process of the ulna, the former especially, as the parts at fault.

I venture to suggest that each of these practical surgeons could have cited cases in proof of his special views; and that, in fact, the conditions met with are anything but uniform. Therefore I think it vain to insist on any one method of reduction as the proper one; each case is to be studied for itself, and such manipulation adopted as seems to promise best. Failing this, some other plan may be tried.

Moore's method is a very good one: he grasps the prone hand of the patient with one hand, the forearm with the other, his thumbs being applied against the head of the ulna so as to act as a sort of double fulcrum. I have once or twice succeeded by using my knee as a fulcrum, grasping the hand and fragment with one hand, while steadying the forearm with the other. Lonsdale[1] says: "The ends of the bone may often be unlocked by suddenly supinating the arm to the utmost."

One thing seems to me of great importance, viz., to act as much as possible directly upon the fragments themselves. Too often extension is made upon the hand alone; and although in old persons, with soft or brittle bones, such a procedure may disengage the lower fragment, yet in others, and especially if the fracturing force have been severe, and if the upper fragment have been strongly driven into the lower, it may totally fail. By such a manœuvre the soft parts may be drawn out into something approaching the normal shape, the fragments still remaining in their false relation, so that no real good is effected. Often, as Hamilton points out, the ligaments are torn. The circumduction recommended by Moore for disentangling the head of the ulna will sometimes free the lower fragment also.

Precise directions cannot, however, be given for every case. It is of the utmost consequence that the surgeon should know what is the normal form which he wishes to restore, and that he should have sufficient ingenuity and mechanical dexterity to ascertain and overcome whatever difficulty may exist in each case, as far as it is possible to do so.

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[1] Op. cit., p. 146.

The fragments having been disengaged, if there have been no crushing of the cancellous substance, their apposition can be readily maintained, and it will be found that the articular face of the bone has resumed its natural position, looking slightly toward the palmar aspect of the limb. The "silver-fork" deformity will be markedly diminished, although it may be that swelling will already have taken place to such an extent as to constitute a fulness on the dorsum of the wrist. The concavity of the palmar surface of the radius will be restored, and, if the hand be placed in a natural position, neither flexed nor extended upon the forearm, the ball of the thumb will be seen to bulge strongly downward, thus apparently increasing the concavity just mentioned. At the same time the ulna will have gone back into its proper place, and the ulnar edge of the wrist and hand will make with it a slight entering angle.

It must be remembered that if there have been crushing of the substance of either fragment, or if the lower one be comminuted, this complete restoration may be impossible, and a certain amount of distortion will remain in spite of the surgeon's best directed efforts. When such is the case, the patient should be notified that he has to expect more or less deformity to be permanent.

In the rare cases in which the displacement has occurred in the opposite direction, namely, with the lower fragment bent toward the palm, the manœuvres must be modified accordingly; the details will readily suggest themselves.

I need hardly say that in cases which present any degree of difficulty, the surgeon's task will be rendered much easier by having the patient in a state of complete anæsthesia.

A very large array of splints has been devised for the treatment of fractures of the lower end of the radius. By the older surgeons, the dorsal and palmar boards were employed, with pads to push the fragments into place. Dupuytren, in the hope of correcting the projection of the ulna and the abduction of the hand, applied a curved bar along the ulnar edge of the forearm and hand; it is best known, perhaps, by its French name, as the "attelle cubitale." The same end has been sought by means of a pistol-shaped board, placed on the dorsum of the forearm and hand; some surgeons have thought that this answered a better purpose if laid along the palmar surface. By most authors this contrivance has been called "Nélaton's splint;" but it is not mentioned in that author's *Pathologie Chirurgicale*, published in 1844. Malgaigne speaks of wooden splints, "which should first cover the forearm in the ordinary way, and which at the wrist should bend sharply inward, not by their surfaces, but by their edges." These, he says, were proposed by Blandin in 1836, but had been "previously known." The fact is that the pistol-shaped splint is clearly described by Goyrand,[1] as an improved form of apparatus devised by himself.

Skey thought that the hand ought to be sedulously supported; Gordon, of Belfast, believes that its weight may be made useful as an adducting force.

Bond's splint, proposed in 1852, has had a very wide popularity in America, and with some modification is a very good one. It consists of a board cut to the outline of the normal hand and forearm, and furnished with a palmar block, over which the fingers are flexed. Leather strips are generally tacked along its edges to keep the parts more secure. This splint is greatly improved by fastening along its radial margin a block of wood, so shaped as to fill up the concavity before noted as normal in this part of the limb. Without this, and especially with the palmar block as large as is usually made, Bond's splint can only keep up the deformity it is meant to correct. I make this statement from the examination of a number of cases treated by most able hands on this plan. Hays's splint, a mere temporary substitute for Bond's, is open to the same objection. Hamilton uses a splint on the same principle, but padded with horsehair, kept in place by a sack-like envelop. He employs a dorsal splint also.

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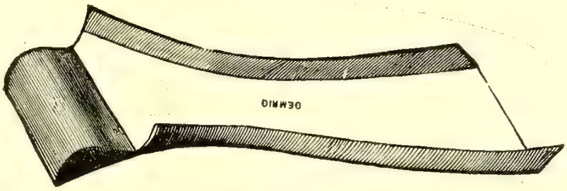
[1] Journal Hebdomadaire des Progrès des Sciences Médicales, Fév. 1836, p. 177.

Fig. 613.

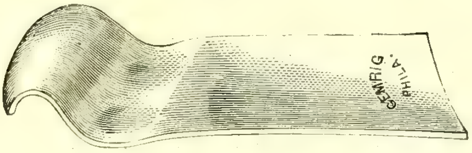


Bond's splint for fracture of the radius.

A number of years ago a splint was made by Carr, a surgeon in New Hampshire, which consisted of a slip of board to fit along the palmar surface of the forearm, narrowing at the wrist, and having nailed across it, by way of palmar block, a cylindrical bit of wood like a section of broomstick (which, I believe, the first one really was). Very good results are said to have been obtained with this, and it is certainly correct in principle. More elaborate and complicated contrivances, on the same general plan, but with adjustable blocks, have been made by others.

Coover's splint, shaped out of wood, so as to fit the palmar surface of the forearm and hand, is sold in pairs, and of various sizes. I have repeatedly used it with great satisfaction.

Fig. 614.



Coover's splint for fracture of the radius.

Levis's splint, made of tin, answers a very good purpose; its shape and mode of use are shown in the cuts, Figs. 615 and 616. A very similar one, of what material is not stated, is described as having been exhibited by Schede, of Hamburg, at a recent congress of the German Society of Surgery.[1]

Gordon's splint deserves mention, although it is awkward in appearance; it consists of a board for the palmar surface of the forearm, with a block along its radial side, filling up the natural concavity of the part. This board extends only as far as the flexure of the wrist, the hand hanging free and tending to adduction. A shaped, dorsal splint, and straps and buckles, complete the apparatus. Both by its contriver and by others it is said to have been found efficient.

Much bolder plans, allowing more liberty to the limb, have been proposed and employed, it is said, with good results. Moore, having effected reduction in the manner before mentioned, applies a small roller firmly over the head of the ulna, and then makes pressure over the injured part by means of a wide band of adhesive plaster. Pilcher discards the compress, and uses the plaster only. I have myself used simply what may be called a very short splint—a slip of wood shaped so as to fill up the concavity just above the wrist, held in place by adhesive plaster first, and then with a bandage. When reduction has been completely effected in simple cases, without comminution, either of these retentive means will suffice; but they must be applied with great accuracy, and should be carefully watched, so that additional safeguards may be resorted to, if necessary.

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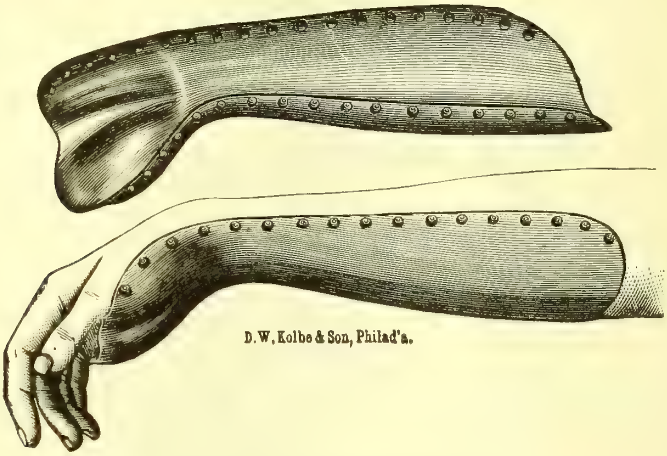
[1] Gaz. Médicale de Paris, 19 Août, 1882.

Figs. 615, 616.


D.W. Kolbe & Son, Philad'a.

Levis's splint for fractured radius.

It should never be forgotten, in dressing these fractures particularly, that undue tightness of the bandage may lead to the most deplorable results. Reduction having been once effected, a properly fitted splint will keep the fragments in place, and permit the arm to be supported without any great constriction. All that is needed is that the roller should be put on snugly and uniformly.

My own rule is to examine the condition of the parts every second day for the first two weeks, although this may be modified if there is no derangement of the apparatus, and if at the third or fourth time the fracture is found in perfectly satisfactory condition. Under such circumstances the interval may be extended to four or five days.

Malgaigne's practice in this respect, as stated by himself, seems to me to be scarcely a safe one to follow. He says:—

> "I remove the apparatus at from the eighteenth to the twenty-second day, to ascertain the condition of things, and to remedy any displacement which may have occurred; after this I do not touch it until the thirtieth day, when I leave the limb entirely at liberty. I would repeat, that by pursuing this method I have always found this fracture one of the easiest to cure, without stiffening, deformity, or the slightest impairment of the motions of the limb; excepting, of course, in those very grave cases complicated with actual luxation of the ulna."

Schede, whose splint has already been alluded to, uses a starched bandage over one of flannel, and makes passive motion every eighth day; removing the apparatus altogether at the end of three weeks. The starched or plaster-of-Paris bandage may, I think, be used with advantage in some cases after the second or third week, especially in the case of a restless child, or when the patient cannot be seen again for some time. Passive motion need only be made in exceptional instances, where there is a strong tendency to stiffening, such as sometimes occurs in old people, or where the violence producing the injury has been very great.

I have recently had under my care a woman who, by a fall on the back of the hand, had a fracture of the radius just above the wrist, with displacement of the lower fragment forward. Her attendant had simply applied a Levis's splint, which of course, in such a case, merely kept up the deformity. (I presume no effort to correct it had been made.) When she came to me, about two months afterward, the wrist was greatly deformed, the hand and fingers flexed, and their nutrition impaired, as shown by the wrinkled, glossy, and shrunken skin. She had constant and severe pain, and the hand was useless. By breaking up the adhesions (under ether), and prolonged treatment in the way of frictions and gentle passive motion, I succeeded in improving the condition of things, but she has not yet regained anything like free use of the hand.

Non-union must certainly be very rare in fractures of the lower portion of the radius. Muhlenberg[1] gives five cases in which this condition obtained in the "lower third" of the bone; but it is not stated that either was one of fracture close to the wrist.

When union has taken place with deformity, if too much time has not elapsed, an attempt may be made to separate the fragments by force, and to bring them into proper relation. Little[2] adopted such a course with success after a period of six weeks. More risk would attend a procedure of this kind, in proportion to the nearness of the fracture to the joint; and in very many cases it would be better to trust to the chance of improvement by the modelling processes of nature.

Fractures of both bones of the forearm are of very frequent occurrence, in children especially. In this respect they differ markedly from the other fractures in this region, which are more commonly met with in adult life. Thus, in the tables given by Flower and Hulke,[3] derived from the records of the Middlesex Hospital for sixteen years, out of a total of 2705 fractures, there were 1142 affecting the forearm, viz., the radius and ulna 191, or about 16 per cent., the ulna alone (including the olecranon) 183, or about 16 per cent., and the radius alone 768, or about 67 per cent. Of these 1142 cases, 401, or 35 per cent., were in subjects below the age of 15; and here the proportions were: for the radius and ulna 119, or over 29 per cent.; for the ulna alone (including the olecranon) 45, or over 11 per cent.; and for the radius alone 237, or over 59 per cent.

With regard to the total of fractures affecting patients under the age of fifteen years, 1154, there were for the radius and ulna over 10 per cent.; for the ulna alone nearly 4 per cent.; and for the radius alone over 20 per cent.

As compared with the grand total of 2705 fractures, the cases under the age of fifteen were: in the radius and ulna over 4 per cent.; in the ulna alone 1 per cent.; and in the radius alone nearly 9 per cent.

Agnew's general table[4] includes 8667 cases of fracture treated at the Pennsylvania Hospital in forty-four years; of these, 1802, or nearly 21 per cent., concerned the bones of the forearm, and were distributed as follows: In the radius and ulna 599, or over 33 per cent.; in the ulna alone 218, or something over 12 per cent.; and in the radius alone 985, or over 54 per cent. The reader will note a discrepancy of result between these figures and those previously quoted, which is sufficient to attract attention, but which it is not easy to explain. Agnew's tables are not so arranged with regard to the ages of the patients as to enable a comparison to be made in this respect.

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[1] Agnew, op. cit., vol. i. p. 768.

[2] Medical Record, March 4, 1882.

[3] Holmes's System of Surgery, 3d ed., vol. i. p. 946.

[4] Op. cit., vol. i. p. 824.

Among the 316 cases of fracture before quoted from the records of the Children's Hospital, in Philadelphia, 105, or a little over 33 per cent., affected the bones of the forearm. Of this number, 36, or over 34 per cent., affected both the radius and ulna; 15, or over 14 per cent., the ulna alone (including the olecranon); and 54, or over 51 per cent., the radius alone.

As to the influence of sex, Malgaigne says that "they are equal in number from two to fifteen years; from fifteen to twenty, there are eighteen males to one female; from twenty to forty-five, the number of men is just double that of the women; after forty-five, the women regain their equality, and even exceed it, being twenty-two to nineteen."

It is in this region, as stated in the early part of this article, that bending or incomplete fracture has been chiefly observed.

The *causes* of fractures of both bones of the forearm are most frequently indirect, such as falls on the hand. The mechanism is not always clear; that is, it does not appear why a fall of this kind should sometimes give rise to fracture of the radius alone, close to the wrist, while in other cases both bones give way in their shafts. Probably it is sometimes due to a difference in the mode of impact, and sometimes to the elasticity and toughness of the radius, and the thickness of the periosteum, which prevents yielding, except at the thinner and less protected position of the shaft, the ulna breaking an instant afterward for want of support.

Direct violence may affect this part of the skeleton in various ways: machinery accidents, falls against resisting objects, crushing forces, as by the passage of a wheel, the kick of a horse, blows, etc. Muscular action, in a case recorded by Malgaigne, and in two other instances,[1] has been known to cause fracture of the forearm.

Occasionally there is double fracture, each bone giving way at two points; and comminution is not seldom met with. Either of these conditions is apt to occur in cases due to direct violence, especially in machinery accidents, as when the arm is drawn around a revolving shaft.

Sometimes the two bones are broken at the same level, but they may give way at different points, and then the fracture of the radius is apt to take place higher up—nearer to the elbow—than the fracture of the ulna. This fact may be accounted for partly by the comparative slenderness of the radius above, and of the ulna below; partly, perhaps, by the muscular attachments of the former bone.

Hamilton mentions one case seen by him, in which "the radius was broken three-quarters of an inch above the lower end, and the ulna about one inch below the coronoid process." This is certainly very rare, and it is to be regretted that no details are given either as to the causation or the ultimate result of the injury. Fractures situated so far apart might almost be considered as wholly separate lesions.

Upon the occurrence of fracture of both bones of the forearm, however caused, more or less displacement of the fragments commonly ensues. Very often the fracturing force has much to do with this, but muscular action can scarcely fail to influence it. The resulting condition may be very simple, but it may be very complex. Sometimes the bones retain their parallelism, but are bent backward, forward, or to either side. Sometimes the two upper fragments are pressed together, and the two lower ones separated, or *vice versa.* Again, either by the fracturing force or by subsequent changes of position of the hand, a twisting may take place which brings the four fragments into most complicated abnormal relations to one another. Occasionally the interosseous ligament is torn at the time of the accident, or it may be penetrated by one of the fragments, and in either case a most puzzling and intractable entanglement may ensue.

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[1] Gurlt, op. cit., Bd. i. S. 244.

Fortunately, such embarrassing conditions are infrequent; in the great majority of cases the forearm is simply bent at an angle, the two bones remaining parallel. Most commonly the angle thus formed is salient on the dorsal surface.

It will very readily be seen, however, that even a slight bending of the bones will do away altogether with the freedom of rotation of the radius upon which the use of the hand so largely depends; and this, whether one bone or both be involved. And if, in addition to the formation of an angle, there is rotation of either of the three fragments which can be so affected (for the upper portion of the ulna is fixed by its connection with the humerus), the limitation of movement may by this fact be made materially greater. Such rotation is most likely to take place in the upper fragment of the radius, acted upon by the biceps and supinator brevis; but it is not impossible that by pronation of the hand, aided by the pronator muscles, the lower fragment of this bone may be turned in the opposite direction. The position of the lower portion of the ulna may be slightly affected by the upper fibres of the pronator quadratus, drawing it toward the radius, but it is more likely to be influenced by the position of the hand.

Whatever abnormalities of relation may be assumed by the fragments, and by means of whatever agencies, the action of the muscles passing down along the forearm can scarcely be ignored among the causes promoting displacement. These muscles, left to themselves, tend to shorten the forearm, and when the continuity of the bones is lost at any point, they must draw the fragments past one another, and in this way aggravate their distortion.

The evils to be apprehended from the changed position of the fragments are not limited altogether to angulation of the bones. Non-union may follow, and so far from the motions of the hand being hampered, the bones may be so loose as to be unavailable for any ordinary purpose. Or the wrong fragments may become attached one to another; or a mass of callus may be thrown out and fuse all the broken ends into a rigid and useless block. Rare as these unfortunate occurrences are, they have been met with, and illustrations of them are to be found in most pathological collections.

The *symptoms* of the fractures in question are not often obscure; deformity is sometimes present in so marked a degree as to reveal at once the nature of the lesion; pain, loss of power in the hand, abnormal mobility, and crepitus, are seldom absent. Hence, the *diagnosis* need not be discussed.

From what has now been said, it will be perceived that the consequences of these injuries may be very disastrous, if, as in cases occurring at sea, no treatment can be had for some time; or if the surgeon be careless or unskilful, or the patient unruly. And although under favorable circumstances good results can generally be obtained, the chance of some degree of impairment of motion should always be borne in mind, and should qualify the *prognosis* given to the patient or his friends.

The *treatment* must be based on general principles, but must be carefully adapted to the features of each case. It consists in the reduction of the fragments to their proper relation, and in maintaining them thus until they have become united.

When the deformity consists in a simple bending of the forearm in either direction, it may often be corrected by the mere application of the surgeon's hands; but sometimes it is necessary to make extension also. During any manœuvre of this kind, the elbow should be flexed to a right angle, and the hand placed semiprone. It is much better to have the extension and counter-extension made by an assistant, leaving both hands of the surgeon free to manipulate the injured part. Along with the extension, some rotary movements may be needful in order to the disengagement of the fragments from one another, or from the interosseous ligament. All this must be done with the utmost gentleness, the amount of force used being determined by the resistance met with ; each movement should be made with a definite purpose, and its effect carefully noted, lest the existing displacement be only increased, and further damage done to the soft parts.

Some idea may be formed beforehand of the objects to be aimed at in this procedure, by a careful study of the seat of fracture, and of the condition of the parts—the degree and direction of obliquity of each fracture, the relation of the fragments to one another, the point at which each bone, but especially the radius, has given way, and the amount of entanglement of the soft parts. But in cases presenting much complexity, there may be much that must be left to be ascertained during the manipulation.

Having brought the fragments into proper apposition, the next point is to keep them so. As to the best mode of doing this, authors are not entirely in accord ; some advising supination of the forearm, others semi-pronation. I think that the rule here should be the same as that given for fractures of the radius alone, viz., that when this bone is broken above the insertion of the pronator teres, supination is best, because it allows the lower fragment to follow the upper ; whereas in fractures below this point the upper fragment is not so liable to be supinated. I do not think that this latter fact is due as much to the action of the pronator teres muscle, as to the greater length of the fragment and the more superficial position of its lower end, making it more controllable. Ramonet[1] thinks that the forearm should be kept in semi-pronation for two weeks, as the most comfortable position ; and that passive motion should then be carefully and skilfully made. Either in supination or in semi-pronation there is no difficulty in maintaining the interosseous space, if the fragments are once properly placed.

The practice of applying an "immediate" roller to the limb is more objectionable here than in any other region of the body, for the obvious reason that its tendency is to press the fragments together, and thus to destroy the interosseous space, and to permanently impair the rotation of the hand.

When the supine position is to be maintained, the best splint for the purpose is the ordinary, anterior, right-angled one, with a small, narrow, firm pad laid along the middle of the forearm part. This pad should reach from about an inch below the elbow to about the same distance above the wrist. It is not intended to be forced in between the bones, but merely to compress the muscles and push them gently into the interosseous space. In some arms a corresponding splint may be employed on the under or dorsal side ; but it must be very carefully applied, and should not extend upward far enough for the prominent ridge formed by the ulna to interfere with its usefulness.

Extension may be made, if necessary, from the end of the upper splint, either by means of a glove with the fingers cut off, or by strips of adhesive plaster. The splint should, therefore, extend two or three inches beyond the ends of the fingers.

Another very good splint in principle, but I should suppose rather more difficult of effective application, is that of Dr. X. C. Scott, already mentioned in connection with the treatment of fractures affecting the radius only.

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[1] On the influence of retraction of the interosseous membrane on the loss of supination in fractures of the forearm ; Archives Génerales, Août, 1881.

In cases suitable for semi-pronation, the best splint is an "internal angular" one, extending from about the middle of the arm to the ends of the fingers, or further, if extension needs to be made. A dorsal splint, padded somewhat more thickly along the middle than at the edges, and extending from opposite the bend of the elbow to a point just above the wrist, should also be employed. These splints should be just the width of the arm at each point; if they are wider, the forearm may be bent toward the radial or ulnar side, and if narrower, the pressure of the bandage may drive the fragments toward one another. Hence my own practice is to shape the splints beforehand by taking an outline from the sound limb, and cutting away the parts outside of this outline.

When binders' board is used as the material for the splints, the ulnar edge of the forearm-part may be slightly turned up, so as to afford support to this portion of the limb.

By most surgeons, anterior and posterior splints are applied to the forearm only, and by many the pads for preserving the interosseous space are thought to be "if useful, intolerable; if tolerable, useless."[1] I can only say that, in my opinion, one cause of disturbance of the fragments, in these cases, is the constant, slight, irregular, but unopposed pulling of the muscles, due to continual slight movements of the elbow; hence I would put the forearm at absolute rest by confining the elbow also. Another disturbing cause is the rotation of the forearm, which is effectually prevented, and the thumb kept upward, by simply adding the arm-part to the palmar splint. As to the pads, the mistake generally made is to have them too large in every way, and thus to get pressure where it is not wanted. I think that they should be exactly adapted in size to the space between the bones in each case, and, above all, that they should not be too long.

I attach much importance, not only to keeping the upper fragments at rest by confining the elbow, but to doing the same for the lower fragments by giving due support to the hand, which should be placed at the proper or natural angle with the forearm, slightly adducted. The hand should never be allowed to hang down, as this would tilt up the lower fragments of both bones, and cause an angle salient toward the radial edge of the forearm. The sling should be wide, and should give the forearm perfect support; but if the previous dressing have been properly done in the manner above described, there can be no risk of bending, even if only a narrow sling be used.

After the first dressing, there may be no occasion to disturb the apparatus for several days, if it continue firm, causing no pain, and if the circulation be shown by the state of the fingers to be properly carried on. The splints should then be removed for the purpose of thorough examination, and immediately reapplied. After this the dressings should be renewed about once in forty-eight hours, and at the end of three weeks very gentle passive motion may be attempted, the surgeon taking hold of the forearm above and below the seat of fracture, and rotating the two parts in exact accord. The fracture remaining firm, at the end of the fourth week the fingers may be left free, and two or three days afterwards the part of the splint corresponding to the hand may be removed, as well as the arm-part. After this the dressing may be left on until it becomes loose, and then, on its removal, it will probably be safe to leave it off entirely.

In children union takes place more quickly; I recently attended a little girl, three years old, whose forearm, broken at about the middle, was quite firm on the fourteenth day.

These fractures afford a striking illustration of the fact, noted in the early part of this article, that the absence of pain or discomfort in a broken limb does not give assurance that it has been properly and efficiently dressed. Not a few cases have been observed in which the fragments have been twisted into utterly abnormal relations, while yet the patient has been wholly unconscious of anything being wrong.

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[1] Caswell, in Holmes's System of Surgery, Am. ed. vol. i. p. 861.

The great risk of gangrene in this part, from too tight bandaging, has already been referred to, and ought always to be borne in mind when the dressings are applied. Sometimes it is questionable whether an accident of this kind is not due to the contact of the fragments with the vessels, which by thorough reduction would have been obviated.

Dr. Hamilton, in his report[1] before quoted, mentions three cases of young children, in which no dressings whatever were employed, yet in which the results obtained were perfect.

He refers to another instance,[2] in which a boy of ten years, after a fracture near the lower end of the forearm, had so great a deformity that refracture was seriously thought of by his attendant; gradually, however, the limb became straight, and eighteen years afterward there was no trace whatever of the injury.

Non-union has occurred many times in fractures affecting both bones of the forearm, and for obvious reasons is a cause of more complete disability here than in some other regions. Moreover, the chance of affording relief by prothetic apparatus is less; so that operative interference is very apt to be called for. References to published cases of this kind may be found in the first part of this article.[3]

Refracture sometimes occurs in the forearm, and may affect either one or both of the bones previously broken. When only one suffers, the other, of course, acts as a splint; when both are broken, the case demands the same care and attention as in the first instance, but union is apt to take place more rapidly.

Compound fractures of both bones of the forearm are very often met with in hospital practice, as the result of railroad and machinery accidents. They vary widely in their extent and gravity, and in the complications which they present. No directions can be given for the management of these injuries when amputation is not called for, other than the general laws elsewhere laid down. Often the real treatment of the fracture can only begin at a comparatively late stage of the case, and with very little hope of saving a shapely and useful limb. Yet it sometimes happens that nature, aided by care, attention, and skill, accomplishes unexpectedly good results; and as even a maimed limb is apt to be better than an artificial substitute, the surgeon's trouble and the patient's endurance will be well expended in its preservation.

Fractures of the Hand.

Fractures of the Carpal Bones.—These have been observed almost exclusively in connection with fractures of the lower part of the radius, and as the result of direct violence. Malgaigne mentions two cases seen by Cloquet, and one by Jarjavay; but he does not say expressly that there was no other lesion present. The scaphoid and semilunar would seem to be the bones almost always involved, as might naturally be expected from their close connection with the radius. I can only say, theoretically, that if by direct violence fracture of these bones alone should occur, inflammation of the neighboring joints would be very apt to follow. The injury would scarcely present any distinctive features, and would be amenable only to the same treatment as a severe contusion of the part. Unless caries or necrosis should ensue, or the inflammation extend to the synovial membrane between the rows of carpal bones, no permanent disability would be likely to result.

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[1] Trans. of Am. Med. Association, 1856, pp. 198 and 199.

[2] Case 28; op. cit., p. 201.

[3] Page 63. See also cases recorded by Dukes (Lancet, Dec. 7, 1878) and by Gant (Ibid., May 8, 1880).

FRACTURES OF THE METACARPAL BONES.—These are not very unfrequent in men of the laboring class. They are sometimes met with in machinery accidents, and then are almost always compound. Indirect violence, either from falls on the hand, or from striking a blow, is a common cause of the simple fractures. I have seen one case, in a powerful sailor, in which necrosis had ensued upon a fracture of the fourth metacarpal bone, sustained by striking another man on the jaw. Malgaigne quotes from Velpeau an instance in which "a water-carrier had his fore and middle fingers pulled upon by a carter with such force as to break the third metacarpal bone." He also quotes from Dupuytren a case in which fracture was due to forcible bending backward of the bone: "Two men were trying which could pull back the other's wrist; their fingers were interlocked, the heads of the metacarpal bones directly opposed to each other, and the phalanges bent back and pressing firmly against the dorsum of the hand; the stronger of the two broke his adversary's third metacarpal bone." Usually only one bone is broken, and the experience of surgeons seems to have been strangely different as to the one most likely to suffer. According to some, it is that of the index finger; according to others, the fourth or fifth. Agnew says that he has never seen fracture of the first named, nor have I; but Hamilton records a number of cases observed by himself.

I have said that these injuries were apt to affect men of the laboring class, but Agnew[1] says that he had one case in a child of three years, and another in a man of eighty-five. Hamilton mentions one in a boy of eight, and another in a young lady of eighteen. Children, from the smallness of the bones, the slight leverage therefore afforded, and their customary protection from the violence apt to cause such fractures, are, in great measure, exempt from them; and the same may be said of women.

The seat of fracture, in cases due to direct force, may be at any point; in such as are produced by indirect violence, the bone is most apt to yield a little below its mid-point, so that the distal fragment is slightly the shorter. The line of fracture is oblique, the proximal fragment being bevelled at the expense of its palmar face.

The *symptoms* are pain and deformity, the distal fragment and head of the bone sinking, so that the knuckle seems to be as it were effaced; there is a dorsal projection at the seat of fracture; abnormal mobility may be very distinct, but is sometimes only slight; crepitation may be felt, but obscurely, from the small size of the bone. The proximal fragment is comparatively fixed, and in the examination the distal fragment must be grasped between the surgeon's thumb and finger, applied on the dorsal and palmar surface of the head of the bone; or it may be moved by means of the finger.

As to the *diagnosis*, although Sir A. Cooper[2] says that the appearance is that of dislocation, I have never seen a case in which a mistake could be made between the two lesions. If there is no prominence at the seat of fracture, there will always be tenderness there, and perhaps a sense of yielding under firm pressure. Cases may, however, occur in which the fracture is situated very near the head of the bone, and especially if swelling comes on rapidly, when the diagnosis is a matter of more difficulty. Such an instance has been placed on record by Townsend.[1] Occurring, as they do for the most part, among people of the rougher class, these fractures are apt to be less carefully looked after than those of greater apparent importance; and hence persistent deformity is often seen, and non-union is occasionally met with. Serious interference with the function of the hand is very rare. Hamilton, however, saw a case in which, the metacarpal bone of the index finger having been broken in striking a blow, suppuration followed, and four months after the injury "there existed complete anchylosis at the wrist-joint, and partial anchylosis in the fingers. The hand was deflected forcibly to the radial side. At the point of fracture the fragments were salient backward and quite prominent, but firmly united." It would seem that here there had been thecal abscess, involving the joints secondarily; but such lesions often occur quite independently of any fracture.

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[1] Op. cit., vol. i. p. 918.

[2] Op. cit., p. 506.

The *treatment* consists in restoring the shape of the bone, by filling up the cavity of the palm with some firm body, such as a ball or a mass of tow, and confining it in place by means of a roller or adhesive plaster. Agnew advises a splint, to extend along the palmar surface from the elbow to the ends of the fingers, with a wad of tow in the palm. I think that the ordinary Bond's splint, with the block cut away into an oval shape, would answer as well. Malgaigne, in one case, found two small transverse splints, well padded, effectual.

Non-union would in most cases be productive of so little real inconvenience, that it would not be justifiable to resort to any operative procedure to remedy it. Possibly, if the metacarpal bone of the index finger were the one concerned, some of the less severe measures might be adopted; but it would be very unfortunate if the result should be thecal abscess, and a great aggravation of the disability.

FRACTURES OF THE PHALANGES are not very uncommon; the bones of the thumb are more rarely broken than those of the fingers. Of the latter, I think the index and middle fingers are most liable to fracture, but the others are by no means exempt; the experience of different surgeons varies in this respect. The distal phalanges would seem to be less apt to suffer than the proximal, and the intermediate ones less than either. These injuries have been met with at all ages, and in both sexes, although men are much more exposed than women to the direct violence which is their usual cause. They are very apt to occur to machinists, masons, etc., and are not unfrequent in baseball players. One case of fracture of the proximal extremity of the index-finger by muscular action, has been recorded by Bellamy.[2] The patient, a man aged fifty-five, made a miss in striking a back-handed blow. It must be obvious that force sufficient to break one of these bones would be very likely to comminute it, and to inflict serious damage upon the soft parts also; hence these fractures are very often compound.

I once saw a separation of the palmar margin of the articular face of the first phalanx of the index finger, in a young lady, caused by a blow against the sharp edge of a bedstead; the fragment was plainly to be felt. No serious inflammation followed, and union took place favorably. Most of these injuries are much more grave. A year or two since I was called into the street late at night to see a gentleman who, in going home, had slipped upon the icy pavement, and catching at a spiked railing, had impaled his middle-finger upon one of the points, splitting the first phalanx from end to end. I had to cut through the soft parts of the side of the finger to liberate the hand. Amputation was unavoidable, and was performed the next day, with an excellent ultimate result.

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[1] Philadelphia Medical Times, Oct. 16, 1871.

[2] British Med. Journal, March 28, 1874.

The *symptoms* need hardly be detailed, as they are those of fractures generally, and from the small amount of covering of the bones are readily to be made out. On account of the strength of the flexors, the deformity is apt to be an angle, salient at the back of the finger; but this rule is not uniform, as the fracturing force may drive both fragments toward the palmar surface. Occasionally these fractures are complicated with dislocation, but this, except in the thumb, is in general reducible without great difficulty. Union almost always takes place without hindrance; but I have reported[1] the case of a child three years old, who had two years previously sustained a fracture of the first phalanx of the thumb, with the subsequent formation of a false joint, and on whom an operation was performed with success.

Necrosis of the fragments sometimes occurs, especially in compound and comminuted fractures; and in these cases more or less thecal inflammation is very apt to ensue, and may travel up and even beyond the wrist. Under the most favorable circumstances some degree of stiffening and deformity is often permanent, although it may not interfere with the usefulness of the finger. Stoker[2] showed to the Pathological Society of Dublin the skeleton of an index-finger, illustrating union of a fracture of the second phalanx. The first phalanx was entire and healthy; the articulation between the first and the second had disappeared, and there was firm osseous union between these bones. Strong ligamentous union existed between the second and third phalanges. Occasionally patients find fingers which are thus stiffened so much in the way that they are anxious for their removal; but in general they learn in time to disregard their presence. A far greater annoyance is sometimes caused by the twisting of a broken finger, so that it either crosses another, or constantly rubs against it in the movements of the hand.

As to the *treatment* of these cases, a good deal of ingenuity has been expended upon the devising of splints of various kinds. I believe that the best plan is to employ a piece of sheet zinc of suitable size, bent up so as to fit the palmar surface of the finger; this being very carefully padded and applied, may be secured by means of the best procurable adhesive plaster, or by a bandage imbued with a solution of silicate of potassium. If sheet zinc cannot be had, small strips of wood may be employed, carefully padded, and placed one on the dorsal and one on the palmar surface of the finger. As a temporary expedient this would answer perfectly. When no other means of solidifying the bandage can be had, flour and white of egg may be employed. The finger should be slightly flexed, but at the joints only. Passive motion may be carefully and gently made at the end of ten days or two weeks.

In cases of *compound fracture* the question of amputation comes up, and must be settled on general principles. Excisions are not available here, and if any portion of bone must be lost, it is better to remove the finger. I have several times seen very unsatisfactory results follow the less decided course.

FRACTURES OF THE LOWER EXTREMITY.

These injuries differ from those of the upper extremity in some important respects. As a general rule, they involve the necessity of confinement, often keeping the patient in bed. The greater size of the bones renders the repair a more tedious process, and entails some additional dangers, as for example, those of fat embolism and of pyæmia. Extension is demanded in a larger proportion of cases, and by more powerful means. All the apparatus used must be on a larger scale. Arrangements must be made for the evacuation of the bowels and bladder, without disturbance of the broken bones. Often the risk of bedsores has to be guarded against.

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[1] Am. Journal of the Med. Sciences, July, 1875.

[2] British Med. Journal, Dec. 31, 1881.

Yet the same general principles are to be observed—the same methods of study, the same rules as to diagnosis, and the same care for the avoidance of deformity.

FRACTURES OF THE FEMUR.

The femur, the largest bone in the body, and the most complicated in shape, is among those most frequently broken. The proportion varies in the experience of different observers, and even in the same hospital at different periods. Gurlt cites tables[1] from which I derive the following statements:—

Middeldorpf, among 325 fractures treated in the Allerheiligen Hospital, at Breslau, from 1849 to 1853, found 25, or something over 7 per cent. of the femur.

Lonsdale, at the Middlesex Hospital, in London, between 1831 and 1837, found among 1901 fractures 181, or over 9 per cent.

Gurlt, in the Hospitals and Surgical Polyclinic in Berlin, from 1851 to 1856, found 510, or less than 12 per cent. out of 4310.

Blasius, in the Surgical Clinic and Polyclinic at Halle, between 1831 and 1856, found 97, or over 12 per cent. out of 778.

Malgaigne, from the statistics of the Hôtel-Dieu from 1806 to 1808, and from 1830 to 1837, embracing 2328 fractures, found that those of the femur were 308, or over 13 per cent.

Lente, studying the records of the New York Hospital between 1839 and 1851, found that out of 1722 fractures there were 280 affecting the femur, or over 15 per cent.

Matiejowsky gives from the Allgemeiner Krankenhaus, at Prague, from 1843 to 1855, 1086 fractures, of which those of the femur were 199, or over 18 per cent.

Thus it appears that, from these seven sources, are derived results varying between 7 per cent. and 18 per cent.; a fact probably to be accounted for partly by the circumstances of the populations from which the patients were respectively drawn, and partly by the fact that, in some institutions, the general statistics are swelled by the inclusion of walking cases, while in others these are referred to dispensaries, etc.

From the statistics of the Pennsylvania Hospital for eighty-seven years, from 1751 to 1838, Wallace gives, out of 1810 fractures, 291, or about 16 per cent. of the femur; while Norris, for the period of twelve years, from 1838 to 1849 inclusive, found among 1441, 195, or over 13 per cent. of the femur. This difference, although not very marked, is not easy to explain. On the other hand, it is readily seen why, out of the 316 cases of fracture before quoted from seven years' records of the Children's Hospital, in Philadelphia, only 14, about 4½ per cent. affected the femur; for by reason of the unwillingness of parents to send their children to public institutions, a large proportion of these cases are treated at their homes.

This statement is singularly at variance with that of Holmes,[2] that "fractures of the shaft of the femur are among the commonest of all fractures in childhood;" and Gurlt's table,[3] of 1383 fractures, arranged according to age, shows, among 330 below the age of fifteen years, 60, or a little over 18 per cent., in the femur.

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[1] Op. cit., S. 6.

[2] Surgical Treatment of Children's Diseases, p. 258.

[3] Op. cit., S. 11.

The records of the Pennsylvania Hospital[1] show, out of 248 cases of fracture of the femur in which the age is noted, 80, or 32 per cent., under twenty years of age; 47, or nearly 19 per cent., between twenty and forty years of age; 71, or over 28 per cent., between forty and sixty; and beyond sixty, 50, or 20 per cent.

The influence of sex on the frequency of occurrence of fractures of the femur is strongly marked, but not equally so with regard to all portions of the bone. During childhood and youth, when the neck of the bone is almost exempt, the number of cases in males is very much greater than that in females. Afterwards, the ratio of the two sexes becomes more nearly equal; but in old age, when the neck is the part of the bone most frequently broken, the proportion of women is in excess.

The analogy which exists between the anatomical form of the femur and that of the humerus obtains also in regard to their fractures. Thus, we have in the femur, fractures of the neck, of the trochanters, of the shaft just below the trochanters, of the shaft in other parts of its length, and of the condyles. But it will be noted that while the upper portion of the humerus, as stated in a previous part of this article, is less frequently broken than the lower, the converse is true of the femur; and the anatomy of the neck of the femur is more complex than that of the condyles, while in the humerus the upper extremity of the bone is much the simpler. The epiphyses of the humerus are far more frequently separated by violence than those of the femur. In fact, according to Holmes,[2] separations of the upper epiphysis of the femur are "unknown, except, perhaps, in the fœtus;" this statement is too sweeping, but the lower is much oftener detached, as will hereafter appear.

A correct knowledge of the external anatomy and internal structure of each portion of the femur is essential to the understanding of its fractures. The general mechanical principles concerned have already been laid down.[3]

FRACTURES OF THE UPPER PART OF THE FEMUR are such as involve the neck of the bone, or the trochanters, or both. On examining a normal femur, it is seen that the neck, projecting upward from the oblique inter-trochanteric line, is set at an angle more or less obtuse with the shaft. In front, the surfaces of the two portions are nearly continuous, whereas posteriorly the line is a very marked ridge, and defines a deep hollow between it and the head. Hence, the greater trochanter projects backward, and the general shape of the neck of the bone is slightly convex in front, deeply concave behind.

The angle at which the neck is set on to the shaft, is found, on comparison of femora from different subjects, to vary considerably. Ward says that it is on an average about 125°. Whether it changes in the same skeleton from youth to old age, has never been determined, although it has been so supposed by almost all writers on anatomy and surgery. Sir Astley Cooper[4] gives a very clear description of degenerative changes seen by him in old bones, and in the excellent illustrations accompanying his text, there may be perceived an arrangement of the cancellous structure, which, as I shall presently try to show, has much to do with the clinical features of all fractures in this region. But although these changes may undoubtedly occur, and are more frequent in old age, they are, I think, only parts of a degeneration which, in some individuals only, affects the entire skeleton. In many old bones no such change is to be noted; the neck is at a very obtuse angle with the shaft, and its structure, like that of the bony system at large, resembles that of most bones at earlier periods of life. On the other hand, as shown by Gulliver,[1] such changes may occasionally occur as the result of injury in young persons and adults.

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[1] Surgery in the Pennsylvania Hospital, p. 280.

[2] Surgical Treatment of Children's Diseases, p. 258.

[3] See pp. 13 *et seq.*

[4] Op. cit., pp. 134 *et seq.*

Another point to be noted, which also varies in different individuals, is the constriction of the neck close to the head. Sometimes very marked, this constriction is in some bones scarcely present at all. When it exists, it must obviously influence the probability of fracture taking place at this point, especially if the nutrition of the skeleton becomes impaired by age or any other cause.

The relation of the head of the bone to its neck also varies. Sometimes the neck extends more upward at the lower surface, so as to give the outline of its junction with the head, as seen either from before or from behind, an S-shape, and so as to lessen the relative length of the upper surface of the neck.

Variations exist also in the actual length of the neck. It is in general proportionate to that of the shaft, but not always so; as, for instance, in dwarfs, or short persons, it is longer, and in very tall persons shorter, than it would be according to such a rule.

The antero-posterior is usually less than the transverse diameter of the cervix.

A careful examination of vertical sections in the length of the head and neck of the femur shows, as pointed out by Ward, Wyman, and others, that a number of the lamellæ, beginning at the upper end of the inner wall of the shaft of the bone, close to the lesser trochanter, diverge upward to the concavity of the thin layer of compact substance covering the head, so as to receive the weight of the body upon their extremities. Another series of columns may be seen running outward from the same point, and meeting other columns running up inward from the outer wall of the shaft; these two sets of columns forming a series of groined arches culminating at the upper wall of the neck of the bone, a little to the inner side of the greater trochanter. By this arrangement, the shifting of the weight toward the outer or upper portion of the head is provided for, the pressure coming in greater degree on the outer wall of the shaft, the inner, however, receiving its share through the inner columns of the arches. The remainder of the lamellæ run in various directions, not capriciously nor at random, but so as to afford in the aggregate a very strong support to the solid but thin wall of the bone.

The capsular ligament, properly so called, extends from the edge of the cotyloid ligament to the base of the neck of the bone; that is, to the root of each trochanter, and to the ridges which connect them before and behind. When laid open, this is found to be lined by the synovial membrane, which is reflected from it to the neck of the bone, the line of reflection not corresponding, however, with that of the attachment of the capsule. A portion of the cervix is, therefore, surrounded only by fibrous tissue, the outer layer of which belongs to the capsular ligament, while the deeper is the periosteum, the two being inseparable by dissection.

I think that generally the distance between the reflection of the synovial membrane and the inter-trochanteric lines is about half an inch; one or two pockets, however, existing, where the joint cavity is somewhat prolonged outward. One of these pockets is usually just within the gemelli muscles in the digital fossa, behind the greater trochanter. Differences exist between different individuals in regard to the precise relative extent of the synovial membrane and the neck of the bone.

An arrangement of the immediate investment of the neck of the femur (called by Amesbury " the close coverings") which seems to have escaped the notice of writers on anatomy, is, I think, of importance. Under this portion of the synovial membrane are often to be noticed, raising it into longitudinal folds, several strong ligamentous bands.[1] (Fig. 617.) Once, in a fresh subject, a vessel of some size was seen by me running along one of these folds. Another subject, a woman, had in each hip-joint three such folds, directed obliquely (spirally) from left to right in that of the left side, and from right to left in that of the right; these were in addition to the longitudinal bands above described.

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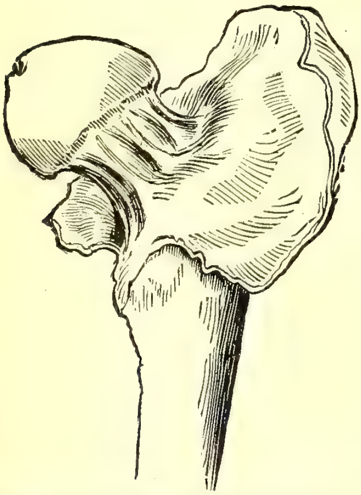
[1] Edinburgh Med. and Surg. Journal, July and October, 1836.

When these folds exist, they must obviously exert an influence in diminishing the chance of fracture of the cervix, and in the event of such fracture, such of them as are unbroken must tend to prevent displacement. Possibly, vessels borne by them may be of importance in the nutrition of the pelvic fragment.

Fig. 617.



Ligamentous bands beneath synovial capsule of hip-joint. (After Amesbury.)

Fig. 618.

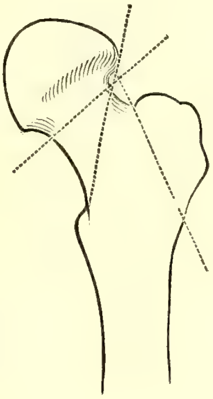


Diagram showing lines of fracture in upper part of femur.

The principal lines of fracture in the upper part of the femur are shown in the diagram. (Fig. 618.) The neck may be broken across just below the head; or the fracture may begin below, just at or near the lesser trochanter, and run up obliquely across the neck, with more or less serration; or the greater trochanter may be broken off. In not a few instances the latter lesion has been produced by the wedge-like action of the pelvic fragment, the main breakage being of the preceding form; and sometimes the lesser trochanter also has been detached. Of course, in such a case, the fracture would be properly called a comminuted one.

In the many and voluminous discussions bestowed upon this subject of fractures of the neck of the thigh-bone, it seems to me that certain facts, anatomical, mechanical, and pathological, have been too much disregarded. The anatomical facts have been set forth above, and the others will presently be mentioned.

Authors have been generally agreed in dividing these fractures into intracapsular, extracapsular, and mixed. Under the first head are those which separate the neck in a direction almost or quite transverse; under the second, those which involve the portion of bone close to the lesser trochanter; and under the third, those which begin near the trochanter and run upward across the neck of the bone to a point close to the margin of the head. But unless the description above given of the extent and attachments of the capsular ligament is incorrect, all these fractures are within the capsule. A more correct phraseology would be "intra-articular" for those which concern the part of the bone beneath the synovial membrane of the hip-joint, and "extra-articular" for those which are wholly outside of it. Of the latter class, I think, very few examples can be found, the great majority of cases being those in which the fracture affects the bone partly beneath the synovial membrane and partly beyond its limits. Bigelow says: "In lecturing upon this subject, I have been in the habit of dividing the injuries of the neck of the femur into the impacted fracture of the base of the neck and the unimpacted fracture of the rest of the neck, without regard to the capsule—a practical classification, embracing a majority of cases, and to which the other lesions may be regarded as exceptional."

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[1] Called by Weitbrecht "Retinacula." They are spoken of by Harrison, in the Dublin Dissector, and by Todd, in the Cyclopædia of Anatomy and Physiology, Art. Hip-Joint.

Viewed mechanically, the femur is a bent lever, arranged for the purpose of receiving the weight of the body, and of being moved so as to transfer it from place to place. Any force brought to bear upon the femur so as to tend to diminish the angle between the neck and the shaft, in other words, any force driving the head downward or the shaft upward, the opposite end being prevented from yielding, may cause a fracture beginning at the lesser trochanter, and tearing away the mass of lamellæ described as radiating upward from that point toward the head. This will only happen if the force is excessive, or if it bears upon the bony texture out of the proper line of transmission of the weight of the body. A blow upon the greater trochanter may do it, or a blow either in front or behind the base of the neck of the bone; in either case the central point of the neck, as it might perhaps be called—the apex of the pyramid of columns—is the starting-point of the rending of the bone. This idea can readily be understood by any one who will carefully examine a vertical section of the upper portion of a well-developed femur. Moreover, such a section will show also how the greater trochanter may be split off.

Out of a very large number of specimens of fracture of the neck of the femur which I have examined, every one which belonged to the "extracapsular" class, that is, every one in which the fracture was not clearly within the limits of the synovial membrane, presented a long point running down close to the lesser trochanter, embracing the lower wall of the neck of the bone, and the pyramidal mass of columns already so often mentioned. And in this statement may also be included all those specimens which would be placed under the head of "mixed." In other words, I feel warranted in saying that all fractures of the neck of the femur are divisible into two classes: one in which the line of separation runs across the neck of the bone between the reflection of the synovial membrane and the margin of the head, the other in which the line begins close to the trochanter and runs up obliquely, and more or less irregularly, to the upper surface of the neck near the head. This long, wedge-like point is very apt to be driven into the cancellous structure of the uppermost part of the shaft, and may split or burst away several fragments of it, one of which will probably consist of the greater trochanter.

By a mechanism not materially different from that now described, fracture may be caused by any force acting upon the shaft of the femur as a lever, the head of the bone being fixed; the enormous advantage afforded by the length of the shaft must be at once apparent.

As to the production of the intra-articular fractures—those in which the neck of the bone is broken nearly or quite transversely—they are generally due, I believe, to a twist impressed upon the part. In some cases this is very obvious, as, for example, when the bone gives way by reason of the patient tripping, or in merely turning around suddenly. Here the great leverage afforded by the length of the femur is almost doubled by the addition to it of the length of the leg; and it can scarcely be a matter of surprise that the neck of the bone should yield.

The accidents which cause these fractures may be various: falls on the feet or knees, driving the femur upward, or falls or blows upon the trochanter, in whatever direction these may come. Sometimes it is difficult to tell whether the fall is the cause or the result of the fracture, in the cases especially of old people, and when the fracture is evidently within the joint.

I may, perhaps, anticipate somewhat here, by saying that in practice the distinction is not always easily drawn between the two forms of fracture. The differential signs so clearly laid down by authors may not exist, or they may be masked by swelling, or by the obesity of the patient.

After what has been said of the mode of production of these injuries generally, it will not be difficult to see how the capsular ligament and periosteum may be only partially torn, and may sometimes even remain entire. Under but slight stress, momentarily sustained, the fibrous structures may be only stretched. If they give way at one part only, that part will correspond to the greatest separation of the bone. Such cases are by no means rare.

One instance is on record, and the specimen is preserved in the Warren Museum,[1] of partial fracture or fissure of the neck of the femur. It was taken from a man aged forty-two, who had fallen through two stories of a building, upon a hard floor. The shaft of the bone was also broken transversely at about the middle. "The fissure involves about three-fourths of the circumference of the neck, the inner anterior portion only being spared; and to a considerable extent it runs along very near to the head of the bone. It is quite closed, but there is considerable motion between the head and neck, when the head and shaft are grasped, and moved upon each other; and the fissure would undoubtedly result in a perfect fracture if much force were used."

Coulon is quoted by Holmes[2] as having seen "the neck of the femur fractured in straightening a diseased hip, though no chloroform was given, and the extension so gently conducted that the child did not cry."

The *symptoms* of fractures of the neck of the femur are very variable in the degree of their distinctness. Cases sometimes occur in which a mistake would be impossible, while in others the utmost care and skill cannot enable the surgeon to arrive at a positive conclusion.

In well-marked cases there is loss of power in the limb, standing and walking are out of the question, and the patient cannot even raise the knee as he lies in bed. The limb is drawn upward, or shortened; this fact being apparent at a glance, and verified by measurement made from the anterior superior spine of the ilium, or from the umbilicus, to the inner malleolus. Various forms of apparatus for making this measurement have been devised by Morton[3] and others, but are scarcely available except in hospital practice, and equally accurate results may be arrived at with a good tape-line, carefully used. The patient should be laid perfectly straight, on a level surface, such as that of a hard mattress, or upon blankets folded and placed on the floor; and care should be taken to have the pelvis exactly transverse. I do not think it of any use to mark the points upon the skin, as is the practice of some surgeons, since such marks cannot but be movable. The tape should be carried from the upper point down along the inner side of the knee to the lower edge of the inner malleolus, on the shortened side first, and then on the normal limb. During this procedure the coverings should be all removed, and the parts concerned completely exposed; although in women the genitals should be concealed by folding in the clothing over them.

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[1] Catalogue, p. 180, No. 1055; see, also, Hamilton, pp. 98 and 396; and Mussey, Am. Journ. of the Med. Sciences, April, 1857.

[2] Surgical Treatment of Children's Diseases, 1st ed., p. 244.

[3] Surgery in the Pennsylvania Hospital, p. 288.

Sometimes the shortening, scarcely perceptible at first, becomes more marked within a few days, and, if uncorrected, continues to increase until it reaches its maximum. Sometimes it is suddenly produced, a week or more after the accident, by the disengagement of the fragments. Sometimes, again, it is at first very slight, but gradually augments as the injured bone undergoes atrophic change.

Besides the measurement of the length of the limb, just mentioned, it is well to determine the distance between the trochanter and the anterior superior spine of the ilium, and so compare it with that on the sound side.

A result of the shortening, to which attention has recently been called by Allis, is the relaxation of the fascia between the trochanter and the crest of the ilium. As a diagnostic sign, it does not seem to me that this would be as valuable as an accurate measurement.

To determine the position of the trochanter several methods have been suggested. Nélaton's line is determined by carrying a tape from the anterior superior spine of the ilium, round the outer side "to the most prominent part of the tuber ischii. In the natural condition, the top of the trochanter in every position is in some part of that line."[1] Bryant drops a vertical line from the anterior superior spine of the ilium to the mattress on which the patient lies, and then ascertains the distance, measured horizontally, from the top of the trochanter to this line.

As a general rule, the foot is everted. So constant is this symptom, that the diagnosis may sometimes be settled in the surgeon's mind, in the case of an elderly patient, by this and the shortening exclusively. It would seem to be due partly to the fracturing force, partly to the weight of the foot and the natural shape of the limb, and partly to the action of the rotator muscles, the glutei especially. A number of cases, however, are upon record in which the foot, instead of being everted, was turned inward,[2] probably by reason of impaction of the fragments. Sometimes, as in a case under Stanley's care, recorded by Ormerod,[3] the foot is neither turned outward nor inward, but remains straight, the explanation being the same. Ormerod says "the neck was broken irregularly, so that the lower portion was wedged slightly into the upper, and overlapped by it in front."

Pain is rarely absent, although it varies in degree. Sometimes it is referred to the groin, a fact explained by the derivation of the nerves supplying the hip-joint from the obturator nerve.

On grasping the thigh and leg, and rotating the entire limb, it will often be found that the trochanter describes a less extensive arc than normally. This, however, is a fact not always easy to verify, and in the case of impaction the fragments may move together, the pelvic one rolling naturally in the acetabulum, so as to be altogether deceptive. Agnew recommends that during this procedure the thigh should be flexed to nearly a right angle with the body. The great leverage given by the leg (the knee being of course flexed also), should not be forgotten, as the fragments may be readily displaced, and damage done.

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[1] Holmes's System of Surgery, 3d ed., vol. i. p. 1003.

[2] Cooper, Dislocations and Fractures, p. 131, *note*, and Case lxxxvii. p. 158. See, also, cases by Guthrie and Stanley, in the Med.-Chir. Transactions, vol. xiii. In Stanley's case the fracture "extended obliquely through the middle of the neck of the femur, but entirely within the capsule." The inversion of the foot led to a suspicion of luxation, and to attempts at reduction. "A portion of the fibrous and synovial membrane on the anterior side of the neck of the bone had escaped laceration." R. W. Smith has recorded several cases. Bigelow mentions one in his work "On the Hip," and Hamilton has seen one. Another instance has recently been reported by Dr. Conklin, of Ohio, in the Columbus Medical Journal for November, 1882.

[3] Op. cit., p. 44.

Crepitus may be elicited by this manœuvre, and is often perceptible even if the degree of impaction be considerable; although in such a case it will be slighter and less distinct than if the fragments are freely movable upon one another. This and the preceding sign are apt to be in the same ratio of clearness.

By Maisonneuve,[1] and more recently by Levis,[2] it has been advised that the patient should be laid on his face, and the limb lifted up from the bed in a backward direction; if the cervix be intact, the movement will be very soon arrested. This procedure should be executed with the utmost gentleness, if at all, on account of the risk of doing mischief by separating the fragments.

Swelling and ecchymosis, although very apt to occur when the injury is the result of force applied over the trochanter, are sometimes wholly wanting when the bone has yielded to slight and indirect violence.

The *course* of fractures of the femoral neck varies greatly, according to the age and constitution of the patient and the character and severity of the local injury. In the old and infirm, there may be such a shock induced as to undermine the general health, and to lead to the extinction of life within a few weeks or months.

Occasionally the fatal result is brought about by suppuration. McTyer[3] recorded the case of a woman, aged fifty-six, who fell on her side, and had afterward a slight halt in walking. She was admitted to the Infirmary, three months after the accident, for "erysipelas in the thigh." A puncture was made, and a large quantity of pus evacuated; the discharge continued, and death took place on the eleventh day. The neck of the femur was broken within the synovial membrane; "the abscess, which was situated in the thigh, communicated through the lacerated capsular ligament with the hip-joint." Reference has already been made[4] to Hunt's case of fracture of the neck of the femur in a man aged twenty-six, who died on the twenty-second day, of pelvic abscess and pyæmia.

More commonly, in the old, the limb remains in a great degree useless, so that the patient becomes either bed-ridden or a cripple. The extent of the loss of power may be, however, but slight, especially if the fracture have been an impacted one. Even when bony union does not take place, there may be such a thickening of the capsule of the joint as to enable the weight of the body to be suspended, as it were, upon the fibrous band so formed. Perhaps the Y-ligament may add firmness to this support; and it would seem that occasionally there are adventitious bands formed, as in an instance reported by Parkman,[5] in which there were shown "certain bands of lymph proceeding from the internal surface of the capsule to the broken surface of the upper portion or head of the bone." Morgagni[6] states that in a case observed by Ruysch, ligamentous union had occurred betwen the broken surfaces, and not, as asserted by Salzmann, through the periosteum alone; and numerous specimens of this kind may be found in museums.

As to bony union between the fragments, there can be no question of its frequent occurrence in cases involving the base of the neck, close to the trochanters, or in what are commonly called extra-capsular fractures. Sometimes it is very firm, and the accuracy of adaptation of the portions of the bone is such that the motions of the joint are very largely recovered. Thus Gant[1] records a case of impacted fracture of the neck of the femur, with slight shortening, in which recovery took place with firm union and a freely movable joint. I exhibited to the Philadelphia Academy of Surgery, a few years since, a man who had, when seventy-two years of age, sustained such a fracture by falling backward upon a pile of timbers; he recovered so completely that it was not apparent from his gait that any injury had ever been received. This man could lift either knee to his chin, could go up and down stairs, and in fact had no disability whatever. A very similar case was reported to Sir A. Cooper,[2] in 1840, by Mr. Sheppard. The fracture, in a man in his sixty-fourth year, was thought to be within the joint; yet at the end of eighteen months he was able to resume his occupation as a mail-coach guard, climbing up and down from his box "with facility, and even dexterously."

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[1] Clinique Chirurgicale, tome i. p. 169.

[2] Philadelphia Medical Times, Jan. 31, 1874.

[3] Glasgow Medical Journal, Feb. 1831.

[4] See page 24.

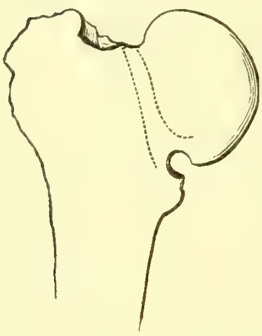
[5] Am. Journal of the Med. Sciences, Jan. 1852.

[6] Op. cit., Letter LVI. Art. 4.

Although bony union may be obtained, and be perfectly firm, yet the motions of the joint may be impaired by either one of two circumstances: the broken surfaces may be so displaced, either by impaction or by sliding past one another, that the extent of motion is limited in one or another direction; or there may be irregular deposits of new bone about the seat of fracture, and these may come in contact with the edges of the acetabulum, or even with the surrounding portions of the os innominatum. On the other hand, there may be absorption of some portion of the fragments, leading to a shortening, perhaps extreme, of the neck of the bone, so that the head rests down against the upper end of the shaft, between the trochanters. A case was recently mentioned to me by Dr. Townsend, of Bridesburg, Pa., in which the neck of the femur was broken, and the shaft was strongly drawn upward. Union occurred between the pelvic fragment and the shaft below the trochanter, so that when the patient recovered he had not only great shortening of the limb, but its abduction was singularly hindered by the contact of the trochanter with the ilium.

The question has been often discussed, whether or not bony union could take place in cases of intra-capsular, or to speak more correctly intra-articular, fracture. A number of instances have been recorded as of this character, and from time to time others are likely to be brought forward. In 1867, I published a paper[3] in which I suggested what still seems to me to be the true explanation of the majority of these cases, namely, that they are originally either wholly or in part outside of the joint, and become solidly united by bone; after which a gradual absorption of the pelvic fragment takes place, allowing the head of the bone to settle down between the trochanters. (Fig. 619.) Since the publication of these views, Professor R. W. Smith has reported[4] to the Pathological Society of Dublin a case of bony union of a fracture, believed to have been within the capsule; and another case was reported by Dr. Senn, of Chicago, to the American Surgical Association, in 1882.[5]

Fig. 619.



Shortening of cervix femoris consecutive to fracture.

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[1] Am. Journal of the Med. Sciences, July, 1866, from Med. Times and Gazette, April 14.

[2] Op. cit., p. 566.

[3] Am. Journal of the Med. Sciences, Oct. 1867. Three cases claimed to have been seen by Fabri (Ibid. Jan. 1863), had escaped my notice, but they are too meagrely described to be of any value.

[4] Dublin Journal of Med. Science, Jan. 1873.

[5] Medical News, June 17, 1882.

But it seems to me that the same explanation applies in these as in the other cases.

I have seen, however, one specimen which I believe to have been unquestionably an intra-articular fracture of the cervix femoris, united by bone. It was presented to the College of Physicians of Philadelphia[1] by Dr. J. M. Adler. The patient was an old lady of sixty-five, paraplegic, who fell out of bed. Her foot was inverted, and the limb shortened; there was pain in the groin and hip-joint, and crepitus. She died five months afterward, and the bone was removed and dried. On its presentation to the College, it was referred to a committee consisting of Dr. A. Hewson, Dr. John Ashhurst, Jr., and myself. We carefully examined it, and reported unanimously that it was an impacted, intra-capsular (intra-articular) fracture, united by bone.

Let me say that some time since, when in Cincinnati, I had an opportunity, by the kindness of Dr. N. P. Dandridge, of inspecting one of the specimens reported and figured by Mussey,[2] and that the line of fracture was readily traceable, extending down close to the lesser trochanter, according to the rule stated on a previous page; thus proving in the case of that specimen that the fracture had not been entirely within the limits of the joint.[3]

Various causes have been assigned for the frequent occurrence of non-union in the intra-articular fractures of the cervix. One, which has been very generally regarded as the chief, is the want of nourishment of the pelvic fragment, which loses all connection with the vascular system except through the ligamentum teres. Another is the excess of synovia formed under the irritation induced by the injury, by which the reparative material is continually washed away from the broken surfaces. Still another, and probably not the least important, is the readiness of movement between the pelvic and distal fragments, which indeed are, in some cases, completely separated. But, however it may be accounted for, the fact remains, and bony union must be regarded as practically unattainable by any care or foresight on the part of the surgeon.

The *diagnosis* of these injuries, although sometimes clear, may present very great difficulties. It is by no means always easy to determine whether the fracture is wholly within the joint, or wholly outside of it, or partly intra-articular and partly extra-articular. When, however, the patient is old and infirm, and the violence inflicted has been very slight, such as is caused by tripping in a fold of the carpet; when the shortening of the limb is immediate and marked; and when there is great mobility of the fragments upon one another, as shown by the ready rotation of the limb, the trochanter describing a small arc—the presumption is that the separation has taken place near the head of the bone.

When the accident has been a severe one, such as a fall upon the hip; if the patient is heavy, and especially if the age is such as to make it improbable that the bones have undergone such degenerative change as to weaken their texture; when the shortening is but slight, and the fragments show no signs of free mobility upon one another, it may be regarded as probable that the fracture is outside of the joint, and that more or less impaction exists.

Prof. R. W. Smith's assertion that "the extra-capsular fracture is always accompanied by a fracture of one or both trochanters" would, if proved, afford a valuable diagnostic sign, as the mobility of the greater trochanter could in general be ascertained, and this, along with the other symptoms, would be conclusive. But, although Prof. Smith adduces a large number of cases in support of his opinion, there are many specimens of the fracture in question, in which the trochanter remains unbroken; and hence this idea cannot form a ground for diagnosis.

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[1] Summary of Transactions, in the Am. Journal of the Med. Sciences, April, 1870.

[2] Am. Journal of the Med. Sciences, April, 1857.

[3] The reader who desires to examine further into this subject will find the references to the supposed cases of bony union in intra-capsular fractures of the cervix femoris in my paper, before mentioned; also in Hamilton's work on Fractures and Dislocations.

The other lesions with which fracture of the cervix femoris may be confounded, and from which it needs to be distinguished, are luxation of the hip-joint, and fracture of the acetabulum. Of the latter, an instance is recorded by Mr. Marsh;[1] the main symptoms were shortening and eversion of the limb, and the true nature of the lesion was only discovered upon examination after death. As to the means of distinguishing fractures about the hip from luxations of that joint, the foregoing discussion of the symptoms of fracture leaves very little to be said. I may, however, again call attention to the fact, elsewhere referred to,[2] that while in luxation there is limitation of passive motion in one or more directions, in fracture it is apt to be rather abnormally free. Great difficulties may, especially in persons below middle age, surround this question. In one instance within my knowledge, a man was twice examined, under anæsthesia, by four experienced surgeons, who decided that he had a fracture of the cervix femoris, but after the swelling had subsided it was discovered that the head of the femur was resting upon the dorsum ilii, and there it remained, all attempts at reduction failing.

After middle life, and in proportion to the development of the peculiarities belonging to advancing age, the chances in favor of fracture as against luxation steadily increase, until in the very old the latter lesion is almost out of the question. The few instances of the kind on record should, however, inspire caution, and prevent too hasty a judgment. Malgaigne quotes without question the observation by Gauthier of a luxation of the hip in a woman of eighty-six, and Hamilton another in a woman of seventy-three, which was unreduced when she was seen thirteen years later. Hence, in any case in which there is room for doubt, a careful and thorough examination should be instituted before pronouncing a positive opinion.

The *prognosis* in these fractures is always grave. Although life may not be destroyed, the chance is that the patient will be a cripple for the remainder of his days, and no surgeon should hold out hopes of complete recovery in such cases. At the same time, much depends upon keeping up the courage of the old and feeble, and it will often require tact and skill to do this.

As to the *treatment*, it must vary with the circumstances of each case. Sometimes all that can be done is to promote the comfort of the patient and to sustain his strength. Often the inconvenience and even distress caused by the application of confining apparatus, especially in cases of very old persons, will outweigh all the advantage derived from it. Yet there are many instances, in those who may reasonably look forward to a considerable term of life, in which suitable treatment may do much to mitigate, if not to prevent, lameness. In the former class of cases, the knee should be supported on a pillow, and the limb placed in the easiest position, with the muscles relaxed. The patient should be allowed to lie as may suit him best; sometimes a reclining chair, enabling him to sit up and lie back alternately, answers an excellent purpose. Bed-sores must be carefully guarded against by cleanliness, by frequent washing of the prominent bony points with whiskey, and by the use of India-rubber air-cushions. Sometimes these cases are complicated by dribbling of urine, especially in old men with prostatic enlargement; and then the bladder should be emptied with the catheter at stated times.

In cases of the other class, extension is called for, and may be best effected by means of adhesive plaster, carried along the entire limb, and attached below to a cord running over a pulley and having a weight at the end of it. This weight need not be more than two or three pounds, and should never be sufficient to annoy the patient. The object is not so much to draw the limb down, as to steady it, and prevent any increase of the shortening. Sand-bags should be placed along the sides of the limb, and the foot should be supported as nearly upright as possible. By elevating the foot of the bed on bricks, the weight of the body is made to afford counter-extension. My own practice is to direct the patient, after ten days or two weeks, to sit up in bed a little while each day, the extension being kept up; thus preventing the hip-joint from becoming stiffened.

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[1] British Med. Journal, March 18, 1882.

[2] See p. 29.

Excision of the detached head of the bone has been proposed, but I know of but one instance[1] in which such a procedure has been adopted, and in that the result was a useless limb. It seems to me that this operation could only be justified in cases in which suppuration had taken place, and that even then its advantage would be questionable. The same may be said of the operative measures proposed, and in a few instances carried out, for fastening the fragments together, and avoiding the non-union so apt to ensue after fractures in this region. Such a course would be useless in the old and feeble, and unnecessary in younger persons, in whom fairly satisfactory results can be obtained by less difficult and less dangerous means.

Fractures of the neck of the femur may occasionally be complicated with luxation of the head of the bone. Such a case was met with by Thornhill,[2] who effected reduction, by means of pulleys, at the end of six weeks. Tunnecliff[3] has reported the case of a farmer, thirty years old, who was caught under a falling tree, and had a fracture of the cervix, the head of the bone being also displaced into the sciatic notch; reduction was accomplished by manipulation on the thirty-eighth day. Another instance was recorded by Douglas.[4] It was observed after death in the body of an old fisherman, who had twelve years previously sustained a hurt. The head of the femur was in the groin, under the middle of Poupart's ligament, "the femoral vein and artery being to its outer side and upon it;" the neck of the bone was broken outside of the capsule. In these cases the luxation must have been first produced and then the fracture; for otherwise there would not have been purchase enough to dislodge the head of the bone.

Mr. Henry Morris[5] recently reported to the Royal Medical and Chirurgical Society a case of impacted fracture of the neck of the femur, in an old man who had for years had an unreduced dorsal dislocation of the same thigh. Under examination the impaction was broken down, and union occurred with the limb in a much better position. Occasionally, but very rarely, the vessels suffer. Thus, Brainard[6] mentions a case in which aneurism of the femoral artery was developed as a result of fracture of the cervix femoris produced by a blow against a wheel; the external iliac artery was successfully ligated. Robinson[7] reported a similar case, in which an operation was proposed, but refused by the patient, who died. No autopsy could be obtained.

Separation of the upper epiphysis of the femur may be mentioned here. It is very analogous to fracture of the neck of the bone close to the head, but occurs, of course, only in the young, the epiphysis uniting with the neck at about the eighteenth year. Another important difference, as appears from the recorded cases, is the much greater violence generally assigned as the cause of the epiphyseal disjunction. Six instances of this lesion may be found described by Hamilton, one of which he himself saw. Hutchinson[1] met with one, and refers to two others. Stimson[2] quotes a case in which the diagnosis was verified by dissection. Dr. J. M. Barton has recently[3] reported the case of a boy of fifteen, in which he suspected a lesion of this character, but the evidence does not seem to me to have been conclusive.

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[1] Howe, Med. Record, Nov. 16, 1878. In the Index Medicus for May, 1882, there is a reference to a work by Wiesenthal: Ueber operative Behandlung intracapsulären Schenkelhalsbrüche durch Excision des abgebrochenen Gelenkkopfes. Halle, 1881. I have not had access to it.

[2] London Med. Gazette, July 20, 1836.

[3] Am. Journal of the Med. Sciences, July, 1868.

[4] London and Edinburgh Monthly Journal of Medical Science, Dec. 1843.

[5] Lancet, Feb. 18, 1882.

[6] Am. Jour. of the Med. Sciences, Oct. 1843.

[7] London Medical Gazette, June 28, 1834.

Far more may be expected from treatment, in a lesion of this kind, than in the fractures which affect the same region in advanced life. Such shortening as exists, may be corrected by extension with the weight and pulley, and the joint may be immobilized by means of a well-applied plaster-of-Paris bandage around the pelvis and thigh. This confinement may be continued, with sand-bags on either side of the limb, and the extension kept up, for two or three weeks in the case of a child; a longer confinement would be advantageous in patients beyond the age of puberty. Cautious experiments should be made at first in allowing flexion of the hip-joint, but if they are productive of no pain or irritation, more and more freedom may be accorded to the patient, until he can move the limb without hindrance; after which, with equal caution, he may be encouraged to put the foot to the ground, and to bear his weight upon it.

A number of years ago, I had a patient, nineteen years of age, who, by a fall from a very high wagon-seat, had sustained a fracture of the cervix femoris, the existence of which was verified, with the patient under ether, by Dr. Nancrede and myself. He was treated in the manner above mentioned, and in six weeks was driving his wagon again, with scarcely any perceptible lameness in walking. My belief is, that the lesion was really a separation of the epiphysis.

Fracture of the trochanter major is by no means uncommon as a complication of fracture of the neck of the bone; and it has been known to occur by itself, but the recorded instances are very few. Mr. Key's case, published by Sir A. Cooper,[4] which occurred in 1822, was the first, as far as I know. It was that of a young girl who fell in the street, striking the trochanter against a curb-stone; the nature of the lesion was only discovered after the patient's death. Mr. B. Cooper[5] gives an account of another case which was seen by him, and in which the diagnosis was justified by the symptoms as described, although the patient recovered, and hence absolute certainty could not be arrived at. The man's age is not stated. Stanley[6] has reported two cases, but in regard to one at least there is room for doubt whether it was not really an ordinary extra-capsular fracture of the cervix, the trochanter also being separated. Bryant mentions one in a boy aged twelve, treated by Mr. Poland. McCarthy[7] reports that a girl of eight, having fallen on her left side, had an abscess in the hip, and that this communicated with one within the pelvis; she had also pyæmia, with pericarditis, pleurisy, and pneumonia, and the trochanter was found detached. Roddick[8] saw a young man, aged sixteen, who had a strain while exercising, and a few days afterward symptoms of abscess about the trochanter, which was found necrosed and separated.

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[1] Med. Times and Gazette, Feb. 24, 1866.

[2] Op. cit., p. 496; from Bull. de la Société Anatomique for 1867.

[3] Medical News, July 14, 1883.

[4] Dislocations and Fractures of the Joints, p. 186.

[5] Ibid., p. 187.

[6] Med.-Chir. Transactions, vol. xiii.

[7] Trans. of the Pathological Society, vol. xxv. London, 1874.

[8] Canada Medical and Surgical Journal, Nov. 1875.

Hamilton[1] quotes from Clarke a case of supposed comminuted fracture of the great trochanter, with the comment that it was probably "an example of fracture of the neck without the capsule, accompanied with impaction and extensive comminution." He also candidly expresses a doubt as to an instance of the kind which he had himself recorded, and upon which he is now inclined to put a similar construction.

F. W. Warren is reported[2] to have shown, at a meeting of the Dublin Pathological Society, a specimen of fracture of the trochanter major, taken from the body of a male subject almost fifty years of age. "It was without history; but from the entire absence of signs of recent injury, and from the fact that the line of separation followed that of the epiphysary junction, the inference seems justified that it was really a case of epiphyseal detachment, dating back perhaps thirty years."

The *cause* of fracture of the great trochanter would seem to be invariably direct violence; and the majority of the subjects are distinctly stated to have been below the age at which this epiphysis becomes united to the shaft. In such cases it may reasonably be supposed that the separation takes place through the cartilaginoid uniting substance, but that, as in separations of other epiphyses, it may in part run through the true bone, detaching a layer of it of very irregular size, shape, and thickness.

The *symptoms* of this lesion can scarcely be confidently detailed from the scanty experience recorded. Some of the symptoms, however, of the usual fractures of the cervix must be wanting; there cannot be shortening of the limb, and in rotating the thigh the trochanter cannot describe a smaller arc than normal, but will either fail to follow the movements of the limb, or if the fibrous coverings are untorn, will behave as under normal conditions.

Pain and disability of the limb must exist, the former being aggravated by pressure on the part; but these symptoms, as well as swelling and ecchymosis, would be equally likely to attend a mere contusion. When the trochanter is broken completely away from the shaft, it will probably be drawn upward, inward, and backward, by the action of the muscular fibres inserted into it; and in such a case it will be transferred from its normal place to that occupied by the head of the femur in backward and upward luxation. Stanley, speaking of the danger of confusion between these two lesions, urges "the positive resemblance of the fractured portion of the trochanter to the head of the femur, the former occupying the same place which the latter would in dislocation; and if with these circumstances there should happen to be an inversion of the injured limb, the difficulty of the diagnosis must be considerably increased." Crepitus would of course be wanting in such a condition of things, and could only be elicited by bringing the fragment again into contact with the surface from which it had been separated.

The *diagnosis* has, perhaps, been sufficiently discussed.

As to the *treatment* of this injury, it need scarcely be said that the attempt should be made to bring back and to hold in place the fragment; but as to the best means of so doing very little is known. Sir Astley Cooper's belt and pad, although theoretically very good, would be difficult to apply in practice, and, unless accurately adjusted, might increase the displacement it was intended to correct. I think that the object could be quite as well accomplished with an ordinary compress, so arranged as to confine the trochanter in its proper position, and kept in place by bands of adhesive plaster. And if the diagnosis were clearly made out, a device, such as that suggested[3] for keeping the fragment of the olecranon in place, might be employed; a double recurved hook, to be driven into the upper part of the separated portion, and attached by means of adhesive plaster to the skin of the limb below.

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[1] Treatise on Fractures, etc., 6th ed., p. 429.

[2] Dublin Journal of Med. Science, July, 1876.

[3] See page 152.

From the slight data available, it would seem that some advantage might be gained by abducting and everting the limb, as suggested by Malgaigne, so as to make the shaft follow the fragment into the position into which the muscles are likely to pull it. It is very probable that the lameness which might be induced by the injury would not, after all, be so serious as to make it worth while to subject the patient to long and rigorous confinement.

Fracture of the lesser trochanter is not described by authors as a separate lesion, although sometimes, as in a case quoted from Guthrie[1] by Sir A. Cooper,[2] it is incidentally mentioned as an attendant upon other and more important injuries.

In 1874 I saw, with Dr. Cohen, an old gentleman, who had slipped on an icy pavement, and in attempting to avoid falling, had met with a hurt about the hip. He could stand, but was unable to walk, and especially to draw the knee up toward the belly, although this position, with the hip-joint flexed, was the most comfortable to him. There was no shortening of the limb, no crepitus, and no eversion of the foot; but there was pain in the groin, and tenderness at the inner and upper part of the thigh. After a time, he got about on crutches, and could even walk a few steps without them; but he never fully recovered the use of the limb. He died five or six years afterward, but no autopsy could be obtained.

I thought at the time, and still think, that in this case there was a tearing off of the trochanter minor; he was very thin, and I could feel the bone on the other side, but possibly the swelling and tenderness prevented my doing so at the seat of injury. I regret very much that the true state of the parts could not be determined by dissection, but feel that even without such completion the case is of sufficient interest to be presented for what it is worth.

FRACTURES OF THE SHAFT OF THE FEMUR are in adults very common accidents. By some authors, those which affect the bone just below the trochanters are placed in a separate class; but although, like those of the surgical neck of the humerus, they present some special features, these are not so marked that they cannot be pointed out in the course of the discussion of the general subject.

The shaft is much more frequently broken in its middle portion than near either end; and this statement holds good in regard to both sexes and all ages. Adult males are more liable to the accidents producing this injury than females or children, and hence afford a majority of the cases. Hofmokl has reported[3] the case of a child, not rachitic, born with a united fracture of the femur, and I have known of more than one instance in which this bone has given way during the process of artificial delivery. When the accident is due to the use of the blunt hook, in breech presentations, the upper portion of the bone is for obvious reasons most likely to suffer.

Looked at from without, the shaft of the femur always presents a more or less marked curve, convex anteriorly, and a slighter curve convex exteriorly. Very rarely it is found to be almost straight. On examination in section, the anterior wall is seen to be thinner than the posterior, where the bony substance is massed into a very thick and strong ridge, the linea aspera. Partly on account of this arrangement, and partly by reason of the bone's curved shape, the direction of fractures in this region is apt to be oblique from above downward and from behind forward. A few instances are on record of almost longitudinal fracture. Thus, in the Warren Museum, there is a specimen[1] described as follows: "The upper portion of the femur, showing a recent and very oblique fracture at some distance below the trochanters; and from it a longitudinal split upwards, and through the great trochanter. Also a fracture of the neck, just above the trochanters." A specimen which is in the Lyons Museum, and photographs of which Mr. Morris showed to the Pathological Society of London,[2] is said to present a fracture extending "from the neck to the lower third, dividing the bone into two almost equal portions, which had united by a few narrow bands of bone." A case of very oblique, almost longitudinal, fracture in a lad, which became the occasion of legal proceedings, has been reported by Dr. Hunt.[3] Spiral fractures have been sometimes observed, as well as fissures; in either case the part affected is more apt to be either the upper or the lower than the middle portion of the bone.[4]

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[1] Med.-Chir. Transactions, vol. xiii.

[2] Op. cit., p. 172.

[3] Archiv für Kinderkrankheiten, Bd. iii. S. 370. Stuttgart, 1881.

Sometimes the bone is broken in two places, as in a specimen in the Museum of the Pennsylvania Hospital,[5] in which "the upper fracture runs obliquely from within outward, and from below upward, about two inches below the trochanter major; the lower one being a jagged, slightly comminuted fracture about three inches above the condyles." Malgaigne mentions that in the Musée Dupuytren there is an example—the only one known to him—of a triple fracture. He does not describe it further.

The *causes* of these fractures are very various. Direct and indirect violence, and muscular action, have all been observed, the second perhaps rather more frequently than either of the others.

Cases of so-called spontaneous fracture are more common in the femur than elsewhere, by reason of the great leverage afforded by the length of the bone. One of the most remarkable of these was recently reported by Rankine.[6] It was the case of "a child aged six years, who, as the mother reported, was simply walking across the floor, when its leg doubled up, the child falling instantly to that side." The femur was found to be fractured in the middle third. The mother declared positively "that she was looking at the child walking over the floor at the time, and that there was no stumbling or anything, but only the leg seemed to double by the mere act of walking. It may be mentioned that the child did not seem to be in the best of health, although nothing very particular could be detected about it." Another case, in a vigorous man aged thirty, is recorded by Gosselin.[7] I have treated a man, about twenty-five years of age, who fractured the shaft of the femur in pulling on a boot; he had done the same thing previously by stepping down from a chair; there was no evidence whatever of constitutional taint or disorder.[8] Humphry[9] records a singular case in which a woman aged fifty-six was twice the subject of apparently spontaneous fracture of the femur; the bone on the right side giving way in May, 1855, and that on the left in March, 1857. On both occasions the affected part had previously been the seat of sharp pains. Union had taken place favorably. But reference has already been made at sufficient length to this subject, in the general part of this article.

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[1] Catalogue, p. 183, No. 1074.

[2] Lancet, Nov. 5, 1881.

[3] American Journal of the Medical Sciences, Jan. 1879.

[4] These spiral, spiroid, cuneiform, helicoidal, or screw-like fractures, as they have been variously named by the authors who have treated of them, are certainly interesting, but I must confess I have never myself seen a specimen of the kind in the femur. Holthouse and Morris (Holmes's System of Surgery, 3d ed. vol. i. p. 1021) give a good description of them, with references to the somewhat scanty literature of the subject. From that source I derive the following: Gerdy, Chirurgie pratique, tome iii.; Féré, Fractures par torsion de la partie inférieure du corps du Fémur; Raullet, Des Fractures hélicoidales (Thèse), 1880.

[5] Catalogue, p. 31, No. 1135^{5}.

[6] Lancet, March 31, 1883.

[7] Clinical Lectures on Surgery, Stimson's Translation, p. 188. Philadelphia, 1878.

[8] The reader will find an interesting paper "On Fractures of the Femur in Adults, without pre-existent Osseous Disease," by Clarence Foster, in the Med. Times and Gazette for July 17, 1880; and another by Vallin, in the same journal for Nov. 6, 1880, taken from the Gazette Hebdom. de Méd. et de Chir. (Paris), 10 Sept. 1880.

[9] British Med. Journal, June 6, 1857.

The femur has been the seat of many of the so-called "spontaneous" fractures in cases of cancer. A remarkable instance of this kind has lately been reported by Mr. Hamilton.[1] It was that of a woman aged fifty-six, who had "a well-marked case of scirrhus," for which the right breast was removed, the wound healing well; about three months afterward, she felt the right femur give way, and fell to the ground. The curious fact in the case is that she ultimately had union, although with four inches of shortening—the latter having been due to her placing herself for a time under the care of an ignorant bone-setter. Generally, a fracture produced under such circumstances fails to unite.

Fracture seldom occurs, except as the result of direct violence, at any point near the middle of the femur. The reason of this would seem to be the fact that the mechanism in other cases is leverage, and that this can scarcely ever be applied so that just the same force shall be exerted on the two halves of the bone. Generally, there is a very great preponderance of force at one end, so that one arm of the lever is virtually much longer than the other.

The immense strain put upon the femur by this leverage is shown by the occasional instances in which even perfectly strong and well-developed bones are snapped under it. I have seen a case in which a man of remarkably robust frame, in running, caught his foot in a hole in the ground, and broke his femur in the middle third.[2] But besides the mere leverage, irregularly exerted as before said, there is another force, a twisting, which cannot be left out of the account, although it is extremely difficult to estimate it with any accuracy. Thus, in the last-mentioned case, the foot being arrested while the momentum of the body carried the upper part of the femur forward, the shaft of the bone was acted upon above through the cervix, while below, at the knee, the condyles were held more or less exactly transverse. Under ordinary stress, such a twist would make no difference; but as the force applied is increased, the effect of the twist is to augment in a still greater ratio the actual resistance demanded of the bone.

It can hardly be maintained that the large and powerful muscles surrounding the femur, and acting upon it either directly or indirectly, are without influence in the production of its ordinary fractures, as they certainly have an effect in keeping up its displacements when broken. But in the former case their action is accessory only, and its degree is not easy to estimate. It probably varies in different cases.

Fracture having once occurred, the fragments may act upon one another to produce still further damage; as in a case reported by Bennett,[3] in which the femur gave way in its upper third, and it seemed clear that the lower fragment was driven into the upper, splitting and fissuring it. Another instance was communicated by Bryant to the Pathological Society of London;[4]

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[1] Lancet, June 2, 1883.

[2] In illustration of the force exerted in such actions, I am tempted to quote from Dr. O. W. Holmes, the following passage: "Walking, then, is a perpetual falling with a perpetual self-recovery. It is a most complex, violent, and perilous operation, which we divest of its extreme danger only by continual practice from a very early period of life. . . . We learn how violent it is, when we walk against a post, or a door, in the dark. We discover how dangerous it is, when we slip or trip, and come down, perhaps breaking or dislocating our limbs, or overlook the last step of a flight of stairs, and discover with what headlong violence we have been hurling ourselves forward."—(Atlantic Monthly, May, 1863.)

[3] British Med. Journal, June 26, 1880.

[4] Transactions, vol. xxix. 1878.

it was the case of a man eighty-three years of age, who died on the twenty-fifth day after the accident, when it was found that the shaft of the right femur "had been clearly fractured at the junction of the middle with the lower third, and the extremity of its proximal end was driven to the extent of an inch and a half into the shaft of the distal portion; this process of impaction splitting the shaft of the distal extremity of the bone, and producing a second fracture of the bone above the condyles."

The *symptoms* of fracture in the shaft of the femur are for the most part of a very pronounced character. Pain is not always present, although it is induced by any attempt at movement, whether active or passive; but there is total loss of power. Deformity is apt to be very marked, the fragments being drawn up at an angle to one another, and the lower one generally rolled outward, the weight of the foot tending to throw it over on its outer side. Often the two broken ends are entirely separated at the anterior part, but posteriorly they are held together by the reinforcement of the periosteum by the strong intermuscular fibrous tissues attached along the linea aspera. This connection may be quite close, but sometimes even here the periosteum is stripped away to a considerable degree, so as to allow a good deal of play to the fragments, and admit of the occurrence of decided overlapping. Swelling quickly takes place, but from the great depth of the bone there may be but slight ecchymosis. Preternatural mobility at the seat of fracture is very perceptible; and crepitus is induced, of course, if the broken ends are rubbed together. Often a mere glance is sufficient to show the nature of the injury. The shortening of the limb, which strikes the eye at once from the position of the foot, may be verified by measurement between the umbilicus, or the anterior superior spinous process of the ilium, and the inner malleolus, as compared with that on the sound side. However carefully made, this measurement is very apt not to be absolutely correct, partly because of the mobility of the skin, and partly because of the difficulty of getting exactly the same bony points on each side. But the matter is really one of small consequence, and it is sufficient if the fact of shortening is made out. Ordinarily the difference between the two limbs strikes the eye at once, and may be from an inch to two or three inches. In one case (the reference to which has escaped me), no treatment having been instituted, the ultimate loss of length was four inches.

Cases are occasionally met with in which *both* femora are fractured, and here comparative measurement is, of course, valueless. One such, occurring to a sailor at sea, is reported by Surgeon H. Smith, U. S. N.[1] Reference will be again made to this condition of things in connection with the modifications demanded by it in treatment. Sometimes the fever is repeatedly broken at the same point, as in an instance recorded by Humphry,[2] in which a woman aged sixty had in 1856 the fourth fracture at the lower part of the bone, the first having occurred in 1847. Firm union took place, but only after the lapse of eighteen weeks.

Gosselin[3] mentions a still more remarkable case, in which a young man of twenty had broken his left femur six times in the course of twenty months. Confinement for three months, with the use of phosphate of lime, was resorted to, and the accident did not again occur.

Fractures of the shaft of the femur are seldom attended with any serious complications. Hammick[4] says that in simple fracture of the thigh he has never seen the large vessels wounded so as to endanger the limb; but he has once seen tetanus. "A filament of the anterior crural nerve was found stretched through a cleft in the bone, so tense as to resemble a violin-string. The patient had broken his thigh at sea, seven days before the arrival of his frigate in the sound."

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[1] Am. Journal of the Med. Sciences, July, 1865. The same number contains an account of another case, in a child aged six, reported by Dr. A. Peter.

[2] British Medical Journal, June 6, 1857. [3] Op. cit., p. 192. [4] Op. cit., p. 74.

Burr, however, has reported[1] an instance of occlusion of the femoral artery from fracture of the femur; gangrene of the leg ensued, and amputation was performed. And Weinlechner met with a case[2] in which the artery and vein were both ruptured, with hemorrhage and consequent gangrene; amputation was submitted to on the third day, but death from septicæmia followed.

Such lesions are much more apt to occur when the shaft of the bone is broken very low down. Thus, Travers[3] relates that "a man broke his thigh; the bone protruded above the patella; at the same time a diffused aneurism of the popliteal artery was produced by a spiculum of the fractured bone penetrating that vessel, though it was discovered only on the fourth day. The femoral artery was immediately tied by Mr. Bransby Cooper, whose patient he was. The ligature came away on the sixteenth day; in another week the aneurismal swelling had disappeared, and the fracture was soundly united in six weeks." Another case is reported by Mr. B. Cooper,[4] in which, the patient having been admitted into Guy's Hospital with compound fracture of the femur, there was so much tension of and injury to the soft parts, that it was thought unadvisable to put the limb in splints. During the night spasm came on, and the femoral artery was lacerated by a portion of the splintered bone coming in contact with it. A ligature was placed upon the vessel, and the fracture united so quickly that Mr. Key remarked of the case, that "the quickest way of producing union of fracture of the femur appeared to be by tying the femoral artery."

Sometimes fractures of the shaft of the femur are complicated with luxation of the hip, as in the case recorded by Murdoch,[5] where the bone was broken in its upper third, and its head lodged upon the ischium; the latter lesion was only discovered after death, which resulted from hemorrhage consequent upon an operation for non-union.

Gayet is reported[6] to have expressed the opinion that hydrarthrosis of the knee was very apt to ensue upon fracture of the femur. Ollier had seen the same in other joints, and thought it might be due to propagation of irritation through the bone. [According to Gosselin, the intra-articular effusion is due to irritation of the outer surface of the synovial capsule, by the extravasated blood which gradually finds its way downward from the seat of fracture; hence this symptom may not be observed until some hours or even days after the reception of the injury.]

The *diagnosis* of fractures of the shaft of the femur does not often present any difficulty. Yet a case was reported, and the preparation shown to the Eighth Congress of the Deutsche Gesellschaft für Chirurgie,[7] in 1879, of amputation of the thigh in its upper part, by Langenbeck, for supposed malignant tumor, in a man aged forty-eight. There was found, however, only a simple fracture, with great separation of the broken ends, excessive growth of callus, and a distinct false-joint. No history of traumatism could be elicited. Analogous cases are said to have been cited by Langenbeck, Martini, Roser, and Kuster.

Such cases are certainly rare; yet, while there can seldom be any trouble in ascertaining the mere fact of the existence or non-existence of fracture, it may be by no means easy to determine the character of the lesion or the direction of the line of breakage: and this obscurity is apt to be the greater, the further the fracture is seated from the middle of the shaft, either upward or downward. In fractures of ancient date it may be extreme. A child about three years old was some time since brought to me on account of a lameness strongly resembling that of hip-joint disease; but, on examination, I found that there had been, just below the trochanters, a fracture of the femur which had united firmly with the fragments at an angle of nearly 90°. The child had, in fact, been allowed to walk while the callus was yet plastic, and the lower fragment had tilted up the distal end of the upper.

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[1] Trans. of Med. Soc. of State of New York, 1873.

[2] Quoted in the Index Medicus for March, 1883, from the Aertzl. Ber. der k. k. allg. Krankenhaus zu Wien, 1882.

[3] A Further Inquiry, etc., p. 436.

[4] Lancet, Dec. 5, 1840.

[5] Trans. of Pennsylvania State Medical Society, 1878.

[6] Med. Times and Gazette, Dec. 30, 1871.

[7] Verhandlungen, S. 30.

The *course* of uncomplicated cases of fracture of the shaft of the femur is generally favorable, union occurring in six or eight weeks in adults, and somewhat earlier in children. Heydenreich[1] has reported a case in which union was firm in thirty-five days, and Henderson[2] one in which an oblique fracture near the middle, in a woman eighty-nine years old, had united solidly on the forty-fourth day. Lee[3] saw a case of union of a broken femur in a man aged ninety-eight. False joint or pseudarthrosis has been met with, and is difficult to manage on account of the great mass of muscle, making it very hard to keep the comparatively small ends of the broken bone together. Operative interference in these cases is attended with peculiar danger; but this subject has been already spoken of in the general part of this article.

Williams[4] has recorded a singular case, in which a man, aged seventy, sustained from direct violence a fracture in the upper part of the lower third of the femur, about half an inch above the point of entrance of the nutrient artery. Union took place with overlapping; the upper fragment was atrophied and conical, the lower presented a good deal of callus, and was of full size.

Union with deformity is of far more frequent occurrence, and, in fact, if all shortening, of whatever degree, be considered as deformity, it may be said to be universal. When the fragments are kept wholly apart, they may altogether fail to unite, but it very seldom, indeed, happens that such is the case. A much more general event is that part of the periosteum remains untorn, and bridges across the interval between the fragments, which thus become connected by means of an intermediate formation of callus. (Fig. 620.) It is astonishing how strong a bone is when united in this way, and how little inconvenience and deformity ensue, provided only that there is a parallelism of the long axes of the two fragments, and that there is no rotary displacement. Of course, however, exact coaptation is far preferable when it can be secured. I shall have to refer to this matter again in connection with the subject of treatment, and hence it need not be dwelt upon just now.

Fig. 620.

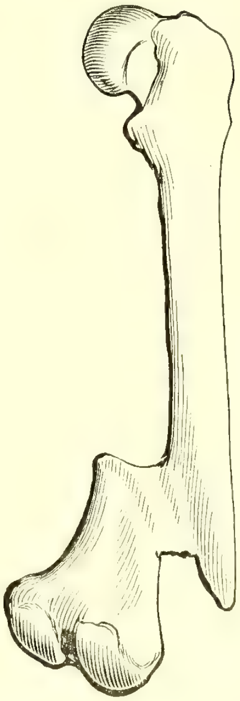

Diagram showing a femur united by a bridge of callus.

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[1] Mém. de la Soc. de Méd. de Nancy, 1882. (Index Medicus.)
[2] London Med. Gazette, Jan. 13, 1843.
[3] St. George's Hospital Reports, vol. iv., 1869.
[4] Dublin Med. Press, April 17, 1844.

From what has been said, it will be inferred that the *prognosis* will vary according to the circumstances of each case. It is certainly better for the surgeon to be very guarded in making promises or predictions as to the result, since the patient or his friends may be greatly disappointed at even a slight and unavoidable degree of deformity. A strong and serviceable limb is in the vast majority of cases obtained, but occasionally there is a permanent halt in the gait.

The *treatment* of fractures of the shaft of the femur is a subject which has engaged the attention of surgeons for a very long time, and upon which much ingenuity has been expended. The end which has been most earnestly sought has been to devise means of making extension and counter-extension, for the purpose of overcoming the shortening which is the most obvious consequence of these injuries. Yet, by some this method has been wholly discarded, and the best results have been claimed from merely putting the limb in such a posture as to relax the muscles. At the present day, there are very able advocates for the use of lateral compression by means of solidifying bandages, to the exclusion of all direct extending apparatus. The adherents of these various plans have for the most part brought forward measurements, purporting to be accurate, of the limbs treated by them, in evidence of the completeness with which shortening was avoided. But I think that to speak of a shortening of an eighth, or even of a quarter, of an inch in the lower extremity, is a refinement beyond practical comprehension. I do not believe that ten, or even five, surgeons, examining a case independently, and without bias as to the method of treatment which had been pursued, would agree within an eighth or a quarter of an inch in their results. Hence I should decline to accept such statements implicitly, regarding them as over-precise. Practically, if a limb is in good line and free from rotary displacement, a shortening of half or three-quarters of an inch is a matter of small moment. Extension and counter-extension ought, in my opinion, to be carefully and effectively made, and the length of the limb maintained as accurately as possible, attention being given quite as sedulously to the preservation of its proper line.

It would occupy too much space to attempt to give here a full description of all the forms of apparatus which have been at various times proposed and employed in the treatment of fractures of the shaft of the femur, although the subject is really one of the most interesting in the history of practical surgery. I shall first describe the method of dressing these injuries which I myself use, and which is employed by many others, and then some of the modifications of it which may be required to adapt it to special cases. Afterward, I shall mention some other plans of treatment, and, lastly, will give briefly some historical points in regard to certain portions of the apparatus.

When a patient with a broken thigh-bone has to be transported to a place where he is to be treated, whether to a private house or to a hospital, especial care should be taken to guard against needless disturbance of the fragments. A very good plan is to take a board about six inches wide, and long enough to reach from the axilla to the foot, and to place this on its edge along the side of the patient. The limb, having been drawn out as nearly as may be to its normal length, may be surrounded with a bundle of straw, or with a folded quilt or blanket, and then bound to the board with a number of broad strips of muslin or linen, the body being also confined in the same way. If another board is now slipped under the pelvis and lower extremities, the patient can be carried very comfortably.

Arrived at the place of destination, a bed is prepared with a firm, hard mattress, perforated or not,[1] and the patient's clothes are removed. As far as possible, the exact seat of fracture is now determined, and the amount of shortening is ascertained by measurement. A strip of good adhesive plaster, about three inches wide, and long enough to reach from the seat of fracture down one side of the limb to four inches below the heel, and up along the other side of the limb to the point of fracture again, is well warmed and applied, leaving a loop of eight inches below the sole of the foot. In this loop is placed a piece of thin board three inches square, and close to it, at either side, a small slit is cut in the plaster, through which a cord or strip of bandage may be passed. Three or four transverse strips of adhesive plaster, or a roller, may be applied to keep the longitudinal strips in exact contact with the skin. A pulley is now placed at the foot of the bed, either on a tripod with one long foot, extending under the bed, and two at right angles to it, or on a rod attached to the bedstead frame with a clamp. An ingenious apparatus for attaching the pulley has been devised by Dr. Sheppard.[1] One form of it is intended for cribs or beds with high foot pieces, the other for the ordinary iron bedstead in use in hospitals. I have sometimes screwed the pulley into the foot-board when the bedstead was so made. In the case of some iron bedsteads, a pulley may be made with a spool and a piece of wire, the latter being run through the former, and then bent up and curved into two hooks to catch on to the bar of the bed-frame.

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[1] See page 56.

The patient is now to be placed in the bed, the foot of which is elevated a few inches by means of a couple of bricks ; the cord is passed over the pulley, and the surgeon proceeds to make extension and to adjust the fragments. Sometimes the services of assistants are required in doing this, and occasionally anæsthesia must be induced. If the limb be a very muscular one, and the displacement great, one assistant may grasp the foot and another the upper part of the thigh ; the force used must be very gentle and gradual, and, while it is exerted, the surgeon carefully handles the fractured part, and coaxes the broken ends into their normal relation. Sometimes, in old people, or in persons of no great muscular development, the adjustment is readily made, and as easily kept up by moderate traction. But in the strong, or in those whose nervous systems are excitable, a good deal of power has to be exerted. The weight to be used depends greatly upon these circumstances ; sometimes it is but small—perhaps two or three pounds—and again it may require ten or twelve pounds to overcome the muscular resistance. One, two, three, or four bricks may be thus used, or bottles of sand, or regular weights placed in a frame ; the latter device is adopted in some hospitals.

Sand-bags, to give lateral support to the limb, are of great service ; they are made of muslin, are long enough to reach, one from the heel to the perineum, the other from the heel to above the crista ilii, and should be ten or twelve inches in circumference. They ought not to be too tightly stuffed, but should be capable of adaptation to the outline of the limb.

Whenever the patient is restless, or if there is a tendency to angulation of the thigh forward or outward, or both (it very seldom bends inward or backward), one or more "coaptation-splints" may be employed. Binder's board or felt answers best for this purpose, a piece of suitable size being softened in hot or cold water, and moulded to the normal shape of the thigh ; after which it is to be carefully padded, and applied with a roller, or with three or four wide adhesive strips.[2] If the foot shows any tendency to displacement, whether outward or inward, this must be carefully corrected, as it indicates rotation of the lower fragment ; and the proper position must be secured by a loop of bandage around the foot, fastened to the sand-bag on the side opposite to that toward which the foot inclines.

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[1] Medical News, Jan. 7, 1882.

[2] The plaster should always be cut for this purpose in the length of the piece, and not across it, lest it should yield and stretch.

Certain details must be attended to in making all these arrangements, in order to the effective working of the plan. The adhesive strips must be smoothly fitted, and not allowed to wrinkle, lest the skin should be irritated; the circular pressure should not be tight enough to obstruct the return of venous blood along the limb; the pulley must be placed at the proper height, and exactly in the line of the long axis of the limb. Should the constant pressure on the heel give rise to any soreness, a mass of carded wool or cotton may be placed a little above, so that the limb may rest on a different point; it is better, however, to guard against any such trouble by protecting the skin with a patch of soft kid spread with soap plaster. The proper adaptation of the weight to the necessities of each case is a matter of much consequence.

It will be perceived that in this plan of treatment the counter-extension is exerted by the weight of the body, by reason of the elevation of the foot of the bed, a device credited by Hamilton to Dr. Van Ingen, of Schenectady. The weight and pulley, distinctly described by Gui de Chauliac in the fourteenth century, was brought forward in modern times by John Bell, in 1801, and in this country, in 1824, by Dr. Luke Howe, and again in 1829, by Dr. Daniell, of Georgia.[1] Its most prominent advocate, however, was the late Dr. Gurdon Buck, of New York, whose name has been generally attached to the method since he revived it in 1861.[2] To show how thoroughly developed it had formerly been, however, I may perhaps quote the following passage from Le Clerc:—[3]

> "To hinder the Patient from turning cross and sliding down toward the Feet of the Bed, you must plant a Stake into the Floor, underneath the Bed, and pass it through the Matting and Bedclothes, so that it may be between the Patient's Legs. This ought to be as thick as the small of the Arm, and covered with some Stuff or other, that it may not hurt the Patient. And for greater security, let it be ty'd with an equal Girth to the Patient's Thigh above the Knee; and let each Branch or Tail of the Girth pass on each side the Knee, exactly on the middle, and over two Pullies (fastened at the end of the Bed's Feet), and at the end of them let there be two Weights suspended to draw the Thigh, and keep it in a streight Posture. The Thigh must be wrapt round with a Bolster in the Place where the Girth is, that it may not hurt it."

When the fracture is very high up, just below the trochanters, there is apt to be not only the drawing upward of the lower fragment, but a tilting upward and forward of the upper one, by contraction of the psoas and iliacus muscles. Perhaps this fragment is also rotated outward by the glutei and other rotator muscles at the back of the hip; but I have never seen this distinctly. Under such circumstances there is so little purchase upon the upper fragment, that it is apt to remain in its abnormal position in spite of every effort to bring it down; and the result is that when union takes place the limb is not only permanently shortened, but deformed and seriously disabled. I believe that in such a case the only resource is to make the lower fragment follow the upper, by raising the knee and flexing the whole thigh upon the pelvis. This may be done by means of the double-inclined plane in some form, or perhaps even by the single inclined plane, as the latter would produce no tension upon the muscles of the front of the thigh. The double-inclined plane is merely a framework, generally hinged so that the angle can be changed at will; one part of it is intended to support the thigh, while the leg rests upon the other, the angle occupying the bend of the knee. Extension may be made by means of a pulley attached either to the apparatus itself, a frame being added for the purpose, or to a standard fixed at the foot of the bed.

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[1] The reader will find an excellent article on the history of this subject, by Dr. E. Hartshorne, in the American Journal of the Medical Sciences for April and July, 1869.

[2] American Medical Times, March 30, 1861.

[3] The Compleat Surgeon, etc. London, 1727.

The single inclined plane, as its name imports, is a board inclined at an angle, upon which, properly padded, one or both of the patient's lower limbs may rest. Extension may be made by means of a pulley fixed at the upper end of the board. One objection holds against both these forms of apparatus; there is much difficulty in preventing the patient from working his body up on to the inclined plane, so as to neutralize its effect more or less completely. Possibly this object might be accomplished by having a perineal block, or a well-rounded upright arranged at a suitable point. But it would perhaps be better to have recourse to one or other of the suspensory splints to be presently described.

Dr. Swinburne, of Albany, advocates[1] the treatment of fractures of the shaft of the femur by simple extension, using a perineal band attached to the head of the bed, and fastening the lower part of the limb to the foot of the bed, by means of adhesive plaster and a cord. Without disputing Dr. Swinburne's statements as to the results obtained by him in this way, I cannot but think that the less rigid methods are at the same time more comfortable to the patient, more adaptable to the varying circumstances under which fractures occur, and more likely to be satisfactory in the hands of most practitioners.

Plaster-of-Paris bandages were strongly recommended a few years ago by Dr. Sands,[2] of New York. They were applied during complete extension, and sometimes under anæsthesia. Whether acknowledged or not, the efficacy of this method must have largely depended upon the extension made against the swell of the leg below the knee, and the counter-extension against the upper portion of the thigh; and the lateral compression must have been at once lost if the thigh itself diminished in size, as it naturally would do from total inaction. My own experience of this plan is limited to a very few cases in children, in which it afforded good results. It seems to me that here, where there is but slight muscular power to be counteracted, and the small size of the bone makes the leverage on the fragments but trifling, the plaster-of-Paris or other solidifying dressing, especially the silicate-of-potassium, is much less objectionable than in the case of adults. Hamilton, however, holds the opposite view. He says: "If I have been unable to give my approval to the treatment of fracture of the shaft of the femur in adults with plaster of Paris, or to any other form of immovable dressing, I am still less able to give it my approval in fracture of the same bone in children." He then relates a case of gangrene in a boy four years old, treated on this plan; but, according to the account, there was unpardonable neglect on the part of the surgeon, and nothing is proved against the treatment if carried out with ordinary skill and judgment.

The method devised by Dr. Nathan Smith, and improved upon by his son, the late Dr. Nathan R. Smith, of Baltimore, has had a wide popularity in this country, especially in the Southern States. As at first made, the apparatus consisted of a wooden splint, cut so as to fit along the front of the entire limb, from the groin to the toes, the hip and knee being each flexed to about 135°. To the under side of this splint the limb was carefully bandaged, and then slung by means of two staples driven into its upper face, one above and the other below the knee. By changing the point of suspension, a more or less considerable degree of extending force was applied to the limb, the weight of the body upon the bed giving the counter-extension.

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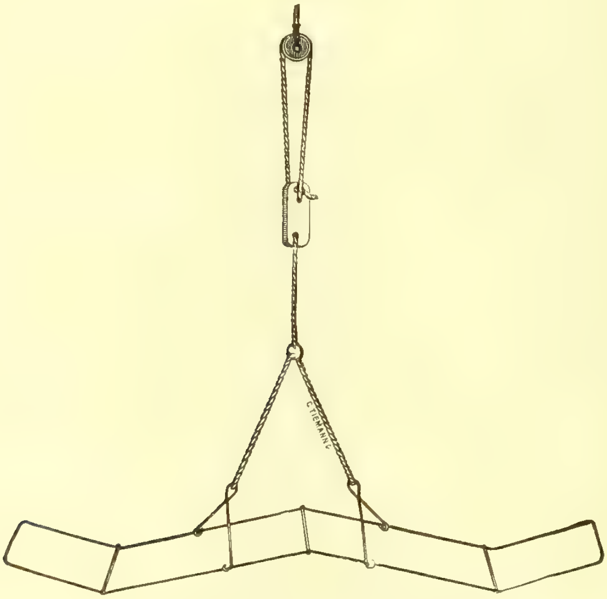
[1] Treatment of Fractures of Long Bones by Simple Extension. Albany, 1861.
[2] New York Medical Journal, June, 1871.

Afterwards, this splint was modified by substituting for the wooden splint a wire frame, suspended by means of wire loops. One advantage of this is that it may be bent so as to suit limbs of various lengths. The cord attached to the splint runs through the loop of another cord, which passes over a pulley fastened in the ceiling, or in a frame over the bed; and this latter cord is passed through what is known as a tent-block, by means of which it may be tightened up or let out, so as to raise or lower the limb at pleasure. (Fig. 621.)

Fig. 621.



Smith's anterior splint for treatment of fractured thigh.

By the late Dr. Hodgen, of St. Louis, a somewhat similar splint was used, but, instead of being bandaged to it, the limb was suspended in it by means of strips of muslin, so that it formed a sort of cradle. (Fig. 622.)

With both these forms of apparatus good results have been obtained in a very large number of cases. Yet in one instance seen by me, that of a man treated by an experienced surgeon, and an enthusiastic advocate of Smith's method, the fragments had united at an angle backward, and such pressure had been made upon the sciatic nerve as to give rise to very serious symptoms, only partially relieved by an operation.

I may mention that Dr. J. R. Taylor, of New York, has recently[1] published an account of a "saddle" attached to an iron brace, and fitting into the perineum, for the purpose of making counter-extension, extension being made by means of a coiled spring. Dr. Brownrigg, of Tennessee, has described[2] an apparatus of his own, in which counter-extension is made by means of a jacket of stout muslin. Neither of these plans seems to me to possess any advantages over other methods more generally known.

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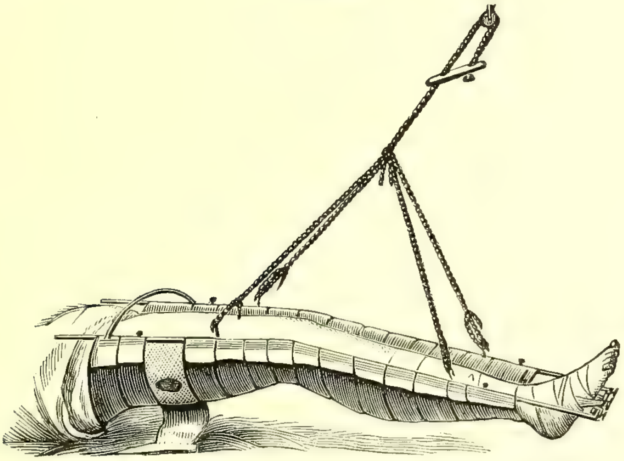
[1] Journal of Am. Med. Association, Sept. 1, 1883.

[2] Trans. of Mississippi State Med. Association for 1881, quoted in the College and Clinical Record for August 15, 1883.

Fig. 622.



Hodgen's suspension splint for treatment of fractured thigh.

Mention has already been made, in a previous part of this article, of certain forms of apparatus known as fracture-beds. These contrivances, of which the best known perhaps were Earle's, Amesbury's, Crosby's, and Burge's, were mostly on the principle of the double-inclined plane, but some of them were arranged for making extension with the limb straight. They were all complicated and expensive, and liable, when used in hospitals, to become infested with bugs. At the present day, I think that they may be said to have been abandoned.

Vertical extension has been recommended in cases of children, by Kümmel,[1] who applies adhesive plaster in the manner before described, and keeps the leg in the vertical position, with the corresponding side of the pelvis suspended by means of a cord fixed to the loop of plaster, and either attached above to some object over the bed, or slung over a pulley, with its free end supporting a weight. A curious effect of this treatment, in female children, is the occurrence of vaginal catarrh, which, however, soon yields to appropriate measures when the extension is no longer kept up. Bryant recommends vertical extension of both the sound and the injured limb.

A few words may now be said as to the development of the present methods of treating fractures of the shaft of the femur, and especially in regard to certain points.

Benjamin Bell[2] describes an apparatus, invented, he says, by Gooch, and improved by Aitken, " which promises to be of the greatest utility in oblique fracture of the thigh." It consists of two leather straps, one buckled around the upper part of the thigh, the other around the lower part; " two or three steel splints, connected with the straps, pass from one to the other in such a manner, that by means of them the straps can be forced asunder," thus making extension and counter-extension. If such an apparatus could be borne by the patient, it would seem that there would be great danger of undue pressure, with serious consequences.

Desault's splint extended from the crista ilii to the sole of the foot. It was notched at either end, and the upper and lower turns of the bandage confining the limb to it were cast through these notches, so as to make an imperfect and inefficient extension and counter-extension. Physick lengthened this splint both ways, extending it up into the axilla, and downward beyond the foot; he also contrived a gaiter to be placed over the ankle, in place of the figure-of-8 bandage previously employed, and introduced the perineal band, afterward padded by Coates, for counter-extension.

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[1] Am. Journal of the Med. Sciences, July, 1882; from Berl. klin. Wochenschrift, No. 4, 1882.

[2] System of Surgery, vol. vi. London, 1788.

Hutchinson added a block on the inner side of the long splint, below the foot, over which the extending band passed, thus bringing the force into line with the axis of the limb.

The introduction of adhesive plaster for securing the extending band to the limb, an invention the paternity of which has never been satisfactorily established, but which is certainly of American origin, was a great step in advance. By Gilbert[1] the use of the same material for counter-extension was strongly advocated.

Yet the extension and counter-extension, however carefully made, were apt to become relaxed, and various means were tried with the view to make them constant. I myself employed an India-rubber "accumulator;[2] and the same idea was subsequently brought forward by Buckstone Brown[3] and others in England. It was not, however, until the revival of the old weight-and-pulley extension that the problem was solved; although, indeed, the suspension splint of Dr. Nathan Smith, before mentioned, may be regarded as capable of answering the same end.

In the foregoing slight sketch, many things have been omitted which would deserve description in a history of the development of the treatment of these fractures. Such are, for example, the inside splint of Physick's apparatus, and the splint-cloth by which it and the other splint were connected; the various forms of apparatus in which it was attempted to "make the sound limb act as a splint for the injured one;" the different arrangements of screws for making extension; and the perineal block for counter-extension. All these devices have been so completely superseded that it seems to me needless to enter into detail with regard to them.

After the descriptions now given of elaborate contrivances for the treatment of fractures of the shaft of the femur, and the importance evidently assigned by surgeons to the prevention of shortening, the reader may well be surprised to know that there have been advocates of the use of a simple roller bandage in these cases. This plan, which is a good deal more than a step beyond that with the plaster-of-Paris or starched bandage, was first proposed by an English surgeon named Radley. Dr. Dudley,[4] of Kentucky, claimed great merit for it, but without succeeding in gaining for it the favor of the profession at large. It would certainly be a difficult matter to convince a jury, if a dissatisfied patient should seek for damages in a case so treated, that due care had been exercised to obtain the best possible result.

Bryant, however, tells us that, in St. Bartholomew's Hospital, both Paget and Callender were in the habit of treating all cases of fracture of the shaft of the femur, in children, without splints or other apparatus; "the child being laid on a firm bed, with the broken limb, after setting it, bent at the hip and knee, and laid on its outer side." Bloxam[5] makes a similar statement.

It may serve as an additional illustration of the diversity of views that may be held on practical subjects, if in contrast with those given on the foregoing pages, as to the necessity of extension and counter-extension in the cases in question, I quote the following: Winchester[1] has advanced the opinion that muscular contraction "is, if rightly understood, a natural power of inestimable value, supplying the exact amount of forcible contact between the broken surfaces necessary to excite healthy reparative action in the most speedy and perfect manner, accurately adjusted to the functional capacity of each individual case."

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[1] Am. Journal of the Med. Sciences, Jan. 1858, and April, 1859.

[2] Ibid., July, 1862.

[3] Lancet, Oct. 10, 1874.

[4] Am. Journal of the Med. Sciences, Nov. 1836; from Transylvania Journal of Medicine, etc., April, 1836.

[5] St. Bartholomew's Hospital Reports, 1867.

When union has taken place with the *fragments in bad position*, in fractures of the shaft of the femur, the correction of the deformity is highly desirable, since, if left to itself, it entails upon the patient a lameness which not only is unsightly and mortifying, but may be a very serious hindrance to his gaining a livelihood. Generally, the best procedure in such cases is forcible refracture under anæsthesia. Numerous instances of this kind have been recorded. Norris[2] gives references, and more or less of detail, in regard to some twenty-five cases, all but three of which were successful. One, operated on by Bontecou, is recorded among the experiences of our late war.[3] Fayrer[4] gives two, in one of which the bone was broken at two points—at the middle and in the lower third. The patient, an English boy fourteen years of age, had met with his accident at sea. Both cases did well. Buck[5] has recorded five. A very remarkable case of multiple fractures, one of which, in the femur, united with deformity and was corrected by re-fracture, is recorded by Tiffany.[6] I myself had occasion, some years since, to rectify a fractured femur in a boy nine years old, which had been badly treated in the country, and had united with marked overlapping as well as slight angle outward; the callus gave way readily under ether, and the little fellow recovered so as to walk without any perceptible limp. It is well to bear in mind that in conducting a procedure of this kind a good deal of force may be saved, by not only bending the bone, but giving it a slight twist also. Extension should be cautiously made in these cases, lest if it be suddenly and too strongly effected, damage should result to the soft parts, and especially to the vessels. I have seen death caused in this manner.

Subcutaneous osteotomy may sometimes be resorted to with advantage, as in a case reported by Verneuil,[7] this plan being preferable when the bone is affected near a joint, or when the injury is of such ancient date that union is probably very firm. The details of the operation are much the same as when it is practised in other cases, and the after-treatment does not differ materially from that of accidental fractures. Resection through an open wound, a procedure attended with much greater risk, was many times practised, and with a considerable degree of success, by the older surgeons.[8] It is now almost wholly abandoned in favor of the improved method just mentioned.

Occasionally, when the callus has not yet become thoroughly solidified, it may be bent into proper shape by firm but gentle pressure applied by means of well-padded splints and compresses, or by bands attached to the bedstead. A case so treated with success at the tenth week, extension and counter-extension being also used, has been reported by Michener.[9]

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[1] Lancet, Aug. 22, 1863.

[2] Contributions to Practical Surgery, pp. 112 *et seq.*

[3] Med. and Surg. Hist. of the War of the Rebellion, Part III., Surgical Volume, p. 651.

[4] Indian Medical Gazette, March 1, 1872.

[5] Transactions of N. Y. Acad. of Medicine, 1855.

[6] Trans. of Medical and Chirurgical Faculty of Maryland, 1874.

[7] Bull. de la Société de Chirurgie, 5 Déc. 1882.

[8] See Norris, op. cit.

[9] Am. Journal of the Med. Sciences, Jan. 1848.

Compound fractures of the femur are always of serious importance, involving a good deal of shock, and presenting sometimes great difficulties in their treatment. When amputation is not indicated, the surgeon has to choose, among the various plans already described, the one which seems best adapted to the circumstances of the case. Often the plaster-of-Paris bandage, fenestrated so as to give access to the wound for the purpose of dressing it, and combined with suspension, presents great advantages. But in the majority of cases, the ordinary arrangement for extension, by the weight and pulley, will answer quite as well, allowing the wound to be dressed and the limb completely supported. I believe this method, carefully carried out and properly watched, to be the best, except in cases of very restless patients, as for example those who have delirium tremens; for such the plaster of Paris, with moulded splints, may be temporarily employed with great benefit. Much depends upon the situation, size, and depth of the wound; and no general rules can be laid down which shall cover the various conditions presented by even a small number of cases.

Fractures of the lower portion of the shaft of the femur are by no means as frequently met with as those higher up in the bone. They have, in most of the recorded cases, affected adult males. Opinions have varied as to their causes; Sir A. Cooper says[1] that they happen "when a person falls from a considerable height upon his feet, or is thrown upon the condyles of the os femoris with the knee bent." Hamilton concurs with him; but Malgaigne says, "These fractures seem to me to be chiefly produced by direct causes." Probably the experience of different surgeons, or of the same surgeon at different times, may differ in regard to this point as upon many others. Malgaigne had seen only two cases from indirect causes, but seven from direct. Among the former cases is perhaps included one previously published by him,[2] to which, however, he makes no reference in his work; the fracture was due to rotation of the knee in an attempt to reduce a luxation of the hip-joint.

However produced, these injuries present very various conditions, differing materially from those of other portions of the bone. At its lower portion, the femur broadens toward the knee, and just above the condyles swells out quite abruptly. Its cancellous structure resembles that of the lower portion of the radius, except that the downward direction of the lamellæ is more distinctly marked; and I think that sometimes the "cross-breaking strain" must be admitted as the true mechanism of its fractures also.

Generally, the principal direction of the fracture is obliquely downward and forward; but Hamilton mentions an instance in which it ran downward and backward, and in which gangrene of the foot occurred, apparently from pressure of the lower end of the upper fragment upon the vessels.

In one case, recorded by the same author, both femora were broken just above the condyles, by a fall from a fourth-story window, the patient alighting upon his feet.

A very singular specimen, in the Museum of the Pennsylvania Hospital, is thus described:[3] "An oblique fracture, which commences at the linea aspera, about six inches above the condyles, and extends spirally inward and downward, completely circling the bone until it reaches within an inch of the condyle. The beginning and end of this line of fracture are united by two other lines of fracture extending upward from the lowest point until they reach the upper end of the spiral fracture. These have separated a bony fragment of the outer part of the shaft from the remainder, and thus completely severed the condyle-portion from the upper part of the bone." The patient, a man aged fifty-nine, had fallen from the height of a ladder. Another specimen in the same museum,[1] taken from a man aged thirty-five, who had also fallen from a height, shows a fracture about two inches below the trochanter major, besides "a jagged, slightly comminuted fracture about three inches above the condyles."

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[1] Dislocations and Fractures of the Joints, p. 244.

[2] Gazette des Hôpitaux, 15 Fév. 1838.

[3] Catalogue (Supplement), p. 37, No. 1141^{15}.

Sometimes, as in two cases recorded by Hamilton,[2] the long anterior point of the upper fragment projects so as to give trouble; in one of Hamilton's cases resection was required in order to effect reduction. Spence[3] has published an account of a very similar case, the sharp point of the upper fragment projecting, covered merely by the skin, and with the patella apparently locked between it and the condyles. Reduction was attempted in vain, and the patient died on the fourth day, having sustained other grave injuries. It was then found that the bone had penetrated through the vastus externus and crureus muscles, and the edge of the tendon of the rectus, on dividing which transversely, reduction became possible. The condyles were found to be separated and comminuted.

Occasionally, the lower fragment is tilted down backward, as mentioned by Boyer, and observed much more recently by Erichsen, Bryant, and others; the displacement is ascribed by these surgeons to the traction exercised by the gastrocnemius muscle, which, it has been proposed, should be relaxed by division of the tendo Achillis. Three cases so treated have recently been placed upon record by Treves.[4] I believe the cause of this rare displacement to be the upward pull of the muscles at the back of the thigh, forcing the lower fragment against the upper, by which it is again pressed backward.

I have cited from Hamilton a case in which the circulation was interfered with by the pressure of one fragment upon the vessels; Laurent[5] quotes a case in which a popliteal aneurism was thus developed, necessitating ligature of the femoral artery. Injury to the peroneal nerve from like cause has lately been reported by Lauenstein.[6]

The *symptoms* and *diagnosis* of fractures of the lower part of the shaft of the femur need hardly be dwelt upon at much length. Pain, helplessness of the limb, swelling, deformity, and crepitus may be looked for. The main difficulty will be to determine the exact extent and direction of the lesion of the bone, and whether or not it involves the joint. For it must be remembered that even if an arthritis be not set up, there will still very probably be some effusion, and that this, along with the rapid swelling of the neighboring soft parts, will obscure the precise condition of the bone. I think that the degree of lateral mobility of the leg upon the thigh (the real point of motion being, however, above the knee) may be, to some extent, relied upon as indicating the state of the condyles; if it is very free, they have probably suffered. Anæsthesia should always be induced for the purpose of making this examination, which should be cautiously and gently conducted; and if the question is not readily settled, it is far better not to be too curious, but to assume that the condyles are involved, and to act accordingly.

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[1] Catalogue, p. 31, No. 1133^{5}.

[2] Op. cit., p. 489.

[3] Am. Journal of the Med. Sciences, July, 1848, from Monthly Journal and Retrospect of Medical Sciences (Edinburgh), May, 1848.

[4] British Med. Journal, Feb. 17, 1883.

[5] Op. cit., Obs. XXI. p. 36.

[6] The quotation is thus given in the Index Medicus for February, 1883; Bruch des Oberschenkels oberhalb der Condylen, Dislokation des unteren Fragmentes nach der Knie-kehle, mit Verletzung des N. peroneus; Befreiung des Nerven durch Resektion des vorspringenden Knochenfragmentes (Fracture of thigh just above the condyles, displacement of the lower fragment toward the ham, with injury to the peroneal nerve; freeing of the nerve by resection of the projecting portion of the bone.) Centralblatt für Chirurgie, Leipzig, 1882. I have not had access to the original account of this case.

The *treatment* of these injuries consists, first, in allaying inflammation by the ordinary means, keeping the joint immovable by placing it on a well-padded back-splint, and employing extension by the weight and pulley from the very outset. After all swelling has subsided, and the parts are again in a healthy condition, the limb may be laid on a pillow, and the extension kept up until the fourth or fifth week, when passive motion may be very carefully tried. Union generally occurs favorably, and, in many cases, a perfect recovery has ensued. Yet it must not be forgotten that there are chances of grave constitutional disturbance, and that in all injuries of large bones, especially in the neighborhood of joints, there are risks which cannot safely be ignored.

SEPARATION OF THE LOWER EPIPHYSIS of the femur is a rare accident, although perhaps it sometimes occurs without being recognized. It belongs, of course, to the period of life in which consolidation with the shaft has not yet occurred, that is to say, before the twentieth year (sometimes as late as the twenty-fifth). As far as I know, in all the recorded instances the patients have been males, and none of them have been over sixteen years of age.

The epiphyseal line is just above the boundary of the knee-joint, and when a separation takes place exactly through it, that cavity will not be involved, although it may become so secondarily. Holmes says:[1] "A reference to such of the published cases of 'separation of epiphysis' as are accompanied by anatomical examination, will satisfy the reader that most of them have been of this nature, viz., injuries in which the line of fracture has been close to the epiphyseal line, and generally, in all probability, corresponding with it in more or less of its extent; but accompanied with fracture in almost all cases, and, therefore, as Nélaton has truly observed, presenting identical symptoms with those of fracture." Sometimes, as in a specimen figured in the work just quoted (Fig. 43, p. 261), another line of breakage extends down between the condyles.

The cause of this injury has been in almost every case, I believe, indirect violence. Madame Lachapelle is quoted by Malgaigne as having seen the lower epiphysis of the femur and the upper one of the tibia separated at once by traction on the foot in aiding delivery. Coural[2] has observed in a boy of eleven years, whose leg was buried in a hole up to the knee, while his body was thrown forward, a separation of the femoral epiphysis; the upper fragment was carried backward, and on proceeding to amputation, which became necessary, the condyles were found in front of the shaft, and so tilted that the articular surface was directed forward. In several[3] cases the injury was the result of entanglement of the leg in the spokes of a wheel. Robson[4] has reported three cases. In one, in a boy of fifteen, hurt in a colliery accident, the lower end of the diaphysis projected into the popliteal space, tightly stretching the large vessels and nerve; in another, in a boy of six, the same deformity was observed; and in both, amputation was necessary. In the third, in a boy of fifteen, caught in a belt and carried around a shaft, there was the same displacement; union occurred, and excision of the knee was ultimately performed with success. In the Museum of the Pennsylvania Hospital, there is a specimen[1] of separation of the condyloid epiphysis, along with transverse fracture in the middle third of the bone, in a boy run over by a railroad car; also another of the former lesion only, without history.

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[1] Surgical Treatment of Children's Diseases, first ed., p. 259.

[2] Fontenelle, Archives Générales, Oct. 1825.

[3] One seen by Hamilton, and two quoted by him. Callender published another in the St. Bartholomew's Hospital Reports for 1873.

[4] Liverpool Medico-Chirurg. Journal, July, 1883.

Even in this small list of cases, the course and results presented a marked variety. Sometimes amputation became necessary, once excision; in Hamilton's case there was anchylosis of the knee-joint, and some shortening of the limb. Callender's patient did much better; union took place in six weeks, and sixteen months later there was no sign of atrophy. Another very favorable result occurred in a case treated by Puzey.[2] A boy aged sixteen was playing leapfrog, and alighted with his legs farther apart than usual; he fell, and was taken to the hospital with one leg at an angle of about 130° with the femur—looking, it is said, like genu valgum. Under ether, the joint was found all right. "The lower end of the thigh was now steadied, and by gently pushing the leg toward the middle line, the limb was straightened, and in so doing there was clearly felt the soft crunch and crepitus which is generally noticed in straightening out a greenstick fracture; further examination made it evident that what had occurred was a separation of the condyloid epiphysis, not quite complete at its upper aspect." Eight months after the accident, this patient was seen again, with a good straight limb and perfect movement of the knee-joint.

As to the *diagnosis* in these cases, very little can be said. The age of the patient, and the characters of the fracture—its want of obliquity, its nearness to the joint, and the smoothness of the fragments—will be the chief points to be relied upon in distinguishing this lesion from ordinary supra-condyloid fracture.

The *treatment* must consist in thorough reduction, and then in placing the limb at complete rest in an easy position, especial care being taken to prevent eversion or inversion of the foot. Extension may be called for if synovitis of the knee should ensue, but need not be as energetically made as in fracture of the shaft. Minute directions need hardly be given as to the means of following out this course, as they do not differ from those employed in other cases.

FRACTURES OF THE CONDYLES OF THE FEMUR are not very seldom met with as the result either of direct violence, as from railroad or machinery accidents, or of indirect, as from falls on the knees. They generally occur in male adults, and present numerous varieties according to the seat and direction of the fracture, the amount of bone involved, the degree of comminution, and the severity of the damage done to the soft parts.

The majority of these injuries affect both condyles, and many of them are T-fractures, the bone being broken across transversely, and the lower fragment split down into the joint. I shall speak first of fractures of this kind, and afterward of those which concern one condyle only.

Sometimes the transverse fracture is quite low down, sometimes much higher. Thus in the pathological cabinet of the New York Hospital there is a specimen[3] "from a man who had had his right knee jammed between the side of a ship and a box of two tons' weight, a few days previous to the amputation of the thigh. The shaft was fractured very obliquely a couple of inches above the condyles, the inner one of which, moreover, had been crushed inward toward its fellow, and was traversed by several gaping fissures, which incompletely separated it into several fragments." Another[4] is described as follows: "Fracture of the femur, four inches above the knee, accompanied by a separation of the two condyles from each other by a line of fracture up at right angles into the one first named. The condyles have united by porous bone situated between their opposed surfaces, while the fracture of the shaft has not united at all, owing, as was found on dissection, to the interposition of a portion of muscle between the fragments."

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[1] Catalogue, p. 31, No. 1132.

[2] British Med. Journal, Oct. 21, 1882.

[3] Catalogue, p. 97, No. 177.

[4] Ibid., p. 98, No. 181.

In the Museum of the Pennsylvania Hospital, there is a specimen[1] showing a transverse fracture an inch and a half above the joint, and a longitudinal fracture completely separating the condyles from each other. In this case the patient, a man, aged nineteen, was caught between two railroad cars; there was great contusion about the knee, and the popliteal artery was ruptured, necessitating amputation.

Again, in the Warren Museum, there is a specimen[2] with the following description: "An oblique fracture just above the condyles; and a second between these two into the knee-joint. The upper fragment is drawn downward in front of, and two inches below, the knee-joint; its pointed extremity being far advanced in the process of separation, and showing finely the contrast between the living and dead bone. A considerable quantity of new and soft bone connects this upper fragment with the shaft above the inner condyle. From an intemperate man, aged thirty-seven years, who slipped and fell with the whole weight of his body upon this limb. On entrance into the hospital (December 20, 1844), there was a shortening of two or three inches. Considerable swelling and emphysema about the knee, and a protrusion of the upper fragment nearly an inch, with great pain and considerable bleeding. The fracture was reduced, but the bones could hardly be kept in place; and on the third day, the extension being discontinued on account of the pain and swelling, the limb was simply laid in a fracture-box. Suppuration and sloughing followed. February 5, the limb was much shortened, and the upper fragment seemed to have penetrated the knee-joint beneath the patella. On the 11th of March it protruded below this bone, and on the 11th of April the man died."

Occasionally there is scarcely a distinct transverse separation, but rather a double oblique one, the upper fragment being obtusely pointed in front, and seeming as if it might have acted as a wedge in bursting apart the condyloid portion of the bone; and I think that this may sometimes be accepted as the true explanation of the mechanism of the lesion. Or, possibly, first one condyle and then the other may have been detached, the end of the shaft being thus, as it were, denuded; such it seems to me was the rationale of Bichat's case, quoted by Malgaigne, in which a man broke the condyles by lighting on his feet.

It will readily be seen that whether the force producing the fracture be direct or indirect, it is scarcely possible for it to act alike on both sides of the bone. Hence, as in some of the instances above cited, one or the other condyle must suffer more severely; and hence there must result a change in the position of the limb, so that an angle will be presented between the shaft of the femur above, and the leg below. Sometimes this angle will be open outwardly, sometimes at the inner side of the limb; and, slight as it may be, it will be so far indicative of the character of the lesion.

In two cases recorded by Callender,[3] the patella had sunk into the space between the fractured condyles, and was so wedged there that its extrication was impossible; the patients recovered slowly, and in each case the knee was rendered permanently stiff.

The *symptoms* are pain, loss of power, deformity, often rendered very obscure by the swelling from effusion into the periarticular bursæ as well as into the joint itself, lateral mobility just above the joint, and crepitus.

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[1] Catalogue, p. 33, No. 1138^{10}.

[2] Catalogue, p. 197, No. 1118.

[3] St. Bartholomew's Hospital Reports, vol. vi. 1870.

When the case is seen very early, the *diagnosis* may present no great difficulty; but from the extreme rapidity with which swelling comes on, and the complexity of the parts involved, the surgeon is rarely able to pronounce upon the nature of the injury without reserve.

The gravity of these cases may be at once perceived. The knee-joint is of necessity involved, and must become the seat of inflammation, so that there is a great risk of anchylosis if the immediate dangers to life are surmounted. Hence a carefully guarded *prognosis* only should be given.

The *treatment* must be directed in the first place to the rectification of any obvious distortion, and then to subduing inflammatory action. During the few hours succeeding the accident, indeed, there may be a very marked collapse, and this must be met as in any other case, bearing in mind the probability of the occurrence of severe reaction in a succeeding stage.

Complete immobilization of the joint, with moderate extension and counter-extension, will I think commend themselves to the judgment of every one as the cardinal principles of the local treatment in these cases. As to the exact means to be employed, there may be room for the exercise of choice. My own preference would be for a well-fitted back-splint, and suspension in either Smith's or Hodgen's wire-frame; but I cannot speak from experience, having never treated a case of this kind except complicated with other injuries which proved speedily fatal. Theoretically, I should think that the comfort of the patient, as well as the retention of the fragments, would be promoted by a slightly flexed posture of the knee, while in the event of anchylosis this would insure a better gait than could be obtained with the limb entirely straight. Should suppuration unfortunately occur, it would be necessary to decide between evacuating the pus and washing out the joint with carbolized water, and amputation; or in young subjects the propriety of excision might be considered.

FRACTURE OF ONE CONDYLE, although more rare than that of both, has been repeatedly observed. All the cases have been in males, and the result of direct violence.

Malgaigne says that this lesion "consists in a nearly vertical division of the bone, striking the articular face near one or the other of the condyles, and directed from before backward, which goes up along the bone, deviating inward or outward, according to the condyle affected, and terminating two, three, or even four inches above the joint; the detached fragment forming a sort of pyramid, with the condyle for its base."

The *external* condyle was broken off in two cases recorded by Sir A. Cooper;[1] in both, however, the shaft of the bone was also fractured across. In another instance, reported by Crosby,[2] the separation of the condyle was due to a twist of the leg, and the fragment was removed by incision some months afterward. Here there may be, perhaps, a question as to the correctness of regarding the force as direct, but I am inclined to think that it was so. Hamilton mentions the case of a man aged forty, seen by him three months after the receipt of the injury; the fragment was then distinctly movable, and he was in doubt whether the fracture had involved the joint. Such a lesion would be analogous to fracture of the epicondyle of the humerus. Kirkbride[3] saw the external condyle separated by the kick of a horse.

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[1] Dislocations and Fractures of the Joints, pp. 241, 242.

[2] New Hampshire Journal of Medicine, 1857.

[3] Am. Journal of the Med. Sciences, May, 1835.

Brookes[1] has published an account of a boy, aged eleven and a half years, "who had his leg entangled in a wheel, and sustained a compound fracture of the femur, extending obliquely downward through the external condyle, which was movable with the lower portion, projecting through a wound in the popliteal space. The leg was twisted inward, much hemorrhage had taken place, and the patient was in a state of collapse. On further examination, the capsular ligament was found to be lacerated, and synovia escaped—the wound in the popliteal space being as large as a five-shilling piece. There was also a simple fracture of the lower third of the same thigh-bone. Amputation having been refused, the limb was put up in the straight position, with a splint extending from the hip to the ankle on the outer side, and a concave one on the inner side of the thigh. Complete union had occurred by the end of the sixth week." At the time of the report the knee could be bent to a right angle, and the entire use of the limb had been recovered; there was no shortening perceptible.

Three other cases are cited by Malgaigne:[2] one seen by himself, another published by Gerdy, and a third, the specimen from which, without history, is found in the Musée Dupuytren.

The *inner* condyle has been observed to be fractured in the following instances: Wells[3] saw a thick scale of bone detached from the inner part of the condyle, the tibia being at the same time luxated outward and backward; the patient could only state that he had fallen. Malgaigne quotes from Boyer[4] a case the account of which is too meagre to be of much interest. The internal condyle was separated, the line of fracture running only a short distance upward; there was no displacement, but manifest mobility of the fragment. Consolidation took place without difficulty, and without apparent deformity. The patient could not walk for three months, and two months afterwards he still limped. Two other cases are cited in the same article,[5] one seen by Malgaigne himself, and the other by Lisfranc. Curtis[6] has published an account of a case seen by him, in which, from the statement made by the surgeon first called, the fragment was displaced backward, the outer side of the limb appearing normal; the joint could not be flexed by reason of the pain caused by bending it. Reduction was easily accomplished, and a good recovery ensued, the joint, however, remaining enlarged. Hamilton quotes a case reported to him by Dr. Riggs, in which, by the kick of a horse, "the internal condyle of the right femur was broken off, carrying away more than half the articulating surface of the joint; the tibia and fibula were at the same time dislocated inward and upward, carrying with them the broken condyle and the patella. The displacement upward was about two inches, and the sharp point of the inner fragment had nearly penetrated the skin. There was no external wound." Great difficulty was experienced in the reduction, but the case ultimately did well.

Two instances are cited by Morris,[7] as follows: "M. Dubue has reported the case of a man aged sixty, who fell while ascending a ladder, and broke off very obliquely the whole of the internal condyle of the femur, and the superior external angle of the patella. Prof. Verneuil had a case in which a large cube of bone, consisting of the inner condyle, was broken off by the falling of a quantity of earth upon a man aged twenty-eight."

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[1] London Med. Gazette, March 10, 1848.

[2] Revue Méd.-Chirurgicale, April, 1847.

[3] Am. Journal of the Med. Sciences, May, 1832.

[4] Traité des Maladies Chirurgicales, tome iii. Paris, 1845. This case does not appear in the earlier editions of Boyer's Treatise.

[5] Revue Méd.-Chirurgicale, April, 1847.

[6] Am. Journal of the Medical Sciences, Oct. 1866.

[7] Holmes's System of Surgery, 3d ed., vol. i. p. 1023.

The *symptoms* of these cases would seem, as far as they have been recorded, to resemble in many respects those of fractures of both condyles; there is the same pain, loss of power, swelling, and crepitus, and in some cases, especially where the bone has been broken higher up also, there would seem to be like deformity. But if one condyle alone is separated, and the case is seen before the parts have been masked by swelling, it may be possible to grasp the fragment by itself, and to move it upon the rest of the bone, so as to gain some idea in regard to it.

The *diagnosis*, however, is extremely difficult in injuries of this portion of the femur; and for my own part, I should be unwilling to make a positive assertion as to any case in which the examination was made after swelling had taken place, unless either the detached fragment was thrown off, or an opportunity for dissection had occurred. I may say that I have seen several cases in which there was reason to believe that one or other condyle had been separated, but it was impossible to arrive at anything approaching to certainty. Theoretically, it is easy to point out what it seems ought to be the signs of one or other lesion; but in practice the matter is far more perplexing.

The *course* of these cases varies very much; sometimes excellent results have been obtained, but in other cases, either from the previous bad habits of the patients, or from the severity of other injuries, the loss of the limb, or even of life, has ensued. When recovery has taken place, the use of the limb has generally been in very great measure restored, and sometimes the cure may be said to have been perfect.

As to the *treatment*, no precise directions can be given, but the general course to be followed is the same as that advised for fractures involving both condyles.

Fractures of the Patella.

According to most observers who have furnished statistics, the patella is affected in something less than 2 per cent. of all the cases of fracture. Gurlt,[1] in the tables before quoted, cites from the record of the Klinik and Polyklinik at Halle, given by Blasius, the statement that out of 778 cases there were 20, or over 2½ per cent., of the patella. On the other hand, at the Allerheiligen Hospital at Breslau, Middeldorpf reported but 3 fractures of the patella out of 325 cases, being less than 1 per cent.

By far the larger number of the subjects of fractured patella are adult males. Agnew[2] says that, in the Pennsylvania Hospital, out of 106 cases 96 were in men and only 10 in women; only one case was seen under twenty years of age, the largest number, 36, occurring between twenty and thirty. Fractures of the patella do not appear at all in the seven years' tables of the Children's Hospital in Philadelphia, already several times cited. Malgaigne's figures are not quite as striking as the above; out of 45 cases, 37 were in men to 8 in women. Of 20 cases observed by himself, only 4 were in women. But 1 of the 45 was in a person under seventeen years of age; one of his own cases, however, was that of a boy of eleven. He calls attention to the fact that in women, from the seventeenth year to the fifty-fifth, there were but 3 fractures of the patella; there were 5 beyond this period.

Rare as this injury is in children, it has been observed in them. Hamilton mentions the case of a boy of five, in whom, by a direct blow, a small piece of the margin of the bone was broken off. Dr. Samuel Ashhurst has reported to the Academy of Surgery, in Philadelphia, the case of a child four years old, who, by a fall, striking the knee against a glass "marble," sustained a fracture of the patella downward and inward.

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[1] Op. cit., Bd. i. S. 6 und 7.

[2] Op. cit., vol. i. p. 971.

The patella may be broken either by direct force or by muscular action, or by both these causes combined. The mechanism by which the bone is made to yield in the first case, is plain enough, as its spongy and easily crushed texture would ill fit it to resist a sudden blow—such, for example, as the kick of a horse. Muscular action does not produce the effect by tearing the bone apart, but by the pull exerted upon the upper portion of the bone, while its lower part is fixed by the ligamentum patellæ, and the resulting leverage over the lower end of the femur. According to this theory, which has received the sanction of most of the leading authorities, this fracture is due, like so many others, to "cross-breaking strain." Malgaigne suggests that in some of these cases the bone has been weakened by previous injury, and that in some there have been pains, or other indications of pathological change; but there have certainly been many instances in which nothing of the kind has been known to have occurred. Perhaps it is too obvious to need argument, that in many cases the muscles are in a state of tension when direct violence is applied to the bone, and that this condition aids materially in overcoming the resistance of its structure.

Desault[1] relates the case of a patient who was cut for stone, and who, in a consequent convulsion, broke both patellæ at once. Marcy[2] reports that a woman, aged thirty-eight, in an effort to save herself from falling, met with the same misfortune. Sir A. Cooper[3] mentions another case, and Johnston[4] another. Callender[5] has recorded one, to be again referred to, and one was seen by Beauvais.[6] Callender has recorded[7] two cases in which a different mechanism was thought to have obtained:—

> "I. M., aged 45, laborer, fell 20 feet, from a ladder, on his knees. There was great effusion into the right knee-joint, with fracture extending through the condyles of the femur, and comminuted fracture of the patella, without much displacement of its pieces. The injury was treated on a double-inclined plane, and the patient was discharged with a useful knee-joint. We had no doubt but that this patella was broken after fracture of the femur, by displaced fragments being driven against the articular surface of the bone. In the museum of St. George's Hospital is a transverse fracture of the patella, without laceration of the fibrous covering of the bone, produced by violence acting from within, in a case of compound fracture of the lower end of the femur, one of the fragments of the femur being driven against the deep surface of the sesamoid bone."

The line of fracture may be almost exactly transverse, or it may be more or less oblique, and in a few instances it has been seen to be longitudinal. One specimen, without history, in the Musée Dupuytren, has been accepted as an example of incomplete fracture, involving only the articular cartilage and a small portion of the underlying bony structure, and not extending to the lateral edges of the bone.[8] It does not seem to me to be unquestionably of the character claimed for it. Sometimes the bone gives way at more than one point. Bryant mentions a specimen, in Guy's Hospital Museum, in which there were four fragments, united by ligamentous bands. There is one in the museum of the Pennsylvania Hospital,[9] described as follows: "The bone has been fractured into five fragments, which are all bound together by a thin, broad layer of fibrous tissue. The distance between the upper and lower fragments is fully $3\frac{1}{2}$ inches, the three other fragments occupying intermediate positions. The surfaces of the fragments have been a good deal rounded off, but are still quite irregular." The patient in this case was known to have twice fractured the bone. Gross[1] figures a specimen in the museum of Prof. Joseph Pancoast, in which there are three fragments, with intermediate bands. No history of double fracture or of re-fracture is given.

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[1] Treatise on Fractures, Luxations, etc. Edited by Bichat. Caldwell's translation, p. 299. Philadelphia, 1817.

[2] Boston Med. and Surg. Journal, October 8, 1874.

[3] Op. cit., p. 230.

[4] Lancet, November 8, 1873.

[5] St. Bartholomew's Hospital Reports, 1870.

[6] Medical Times and Gazette, Oct. 9, 1880; from L'Union Médicale.

[7] St. Bartholomew's Hospital Reports, 1870.

[8] Holmes's System of Surgery, 3d ed., vol. i. p. 1028.

[9] Catalogue, p. 35; No. 1146.

Lonsdale speaks of having seen a man who "fell and struck his knee against the edge of a curb-stone; the fracture took a direction so as to leave the lower portion projecting angularly upwards, fitting into the upper." In comminuted fractures, there is not unfrequently a line of separation more or less transverse, and the lower fragment is again divided by one or two splits running downward from this main fracture.

An anatomical point of importance is well set forth by Tillaux[2] in regard to the connections of the patella. He describes the "lateral ligaments" of the bone as continuous with and arising from the ligamentum patellæ. Strongly attached to the lateral borders of the patella, where they (the ligaments) are very thick, they pass backward, surround the condyles, and are inserted into the fibro-cartilaginous capsule with which the gastrocnemii are connected. These lateral ligaments, he says, "constitute a powerful protection for the front of the knee, and play an important part in fractures of the patella, according as they are more or less torn. When they are but slightly torn, or not at all, as happens in fractures by direct violence, which, indeed, are the rarest, they hold the fragments together; if, on the other hand, they are much lacerated, the unopposed quadriceps muscle drags the upper fragment upward, until it may be separated from the lower by several fingers' breadths. This point must be taken into the account in estimating the value of different methods of treating these fractures, since in the one case the fragments remain in contact, of themselves, while in the other it is difficult to control them even with the best contrived means."

When transverse fracture of the patella occurs, the lower fragment remains in place, being attached to the tibia by the very strong and unyielding ligamentum patellæ. But there are two agencies by which the upper fragment may be separated from it, so that there exists a perceptible gap between them. One, already alluded to, is the contraction of the quadriceps muscle; the other is effusion of serum, and sometimes of blood also, into the knee-joint. Both of these, it must be obvious, will be limited in their action by the lateral ligaments of which I have just quoted Tillaux's description; but the muscle may be powerful enough to tear the ligaments, and thus to produce the displacement. Indeed, it may well be doubted whether it is not in this way that laceration of the ligaments always occurs, since they can seldom be directly ruptured by the fracturing force except just at the edges of the bone; yet having given way here, their further tearing can scarcely require any very great force. Once torn, however, the greatest obstacle both to muscular action and to effusion into the joint is removed; and separation of the fragments will very soon take place.

It must not be forgotten that the strength of these ligaments varies in different individuals; and it is doubtless for this reason, as well as because of the varying degree of the violence sustained, that in some cases there is at once a wide gap between the portions of the bone, while in others the fragments remain almost in contact until inflammatory effusion occurs in the joint.

Mr. Jonathan Hutchinson[3] maintains that the quadriceps extensor muscle is singularly inactive in cases of transverse fracture of the patella, and that the separation of the fragments is due largely to fluid pressure from within the joint. He says that the muscle occasionally undergoes marked and permanent atrophy.

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[1] System of Surgery, vol. i. p. 1000.

[2] Anatomie Topographique, p. 1103.

[3] Med.-Chir. Transactions, vol. lii. 1869.

Vertical or longitudinal fractures of the patella are always due to direct violence, and differ from the transverse in the much less separation of the fragments. Dupuytren[1] gives four cases of this kind, in one of which it is stated that the bone was divided into two nearly equal portions. He speaks of having treated several other cases at the Hôtel Dieu, and thinks them less rare than they have been generally supposed to be. Lonsdale, Cooper, and others, have met with them in the dead subject. The literature of the subject is very scanty, and I know of no recent reports of such cases.

Rupture of the prepatellar bursa is very apt to occur, whether the bone gives way to direct violence or to muscular action; in the former case it is by bursting, in the latter by tearing of its posterior wall. It is not of any importance as compared with the lesion of the bone.

The *symptoms* of this fracture are generally well marked; the patient falls—and sometimes it is difficult to say whether the fall is the cause or the result of the injury to the bone; there is pain, aggravated by the strain upon the fibrous structures surrounding the bone which must attend any attempt at movement; there are swelling and deformity, and, unless the upper fragment has been dragged away entirely from the lower, crepitus is very easily elicited.

These symptoms are by no means always equally clear. Trésoret[2] has published an account of a robust man of forty-five, who struck his left knee in a fall. He kept at work for three weeks, and then, examining his knee on account of its being swollen, he thought that the bone was broken. Two months after the accident, he applied for advice, when a transverse fracture between the middle and lower thirds of the bone was easily detected. A cyst (?) had formed at this point; iodine was injected, and a month afterward the patient was considered as cured. Morris[3] mentions the case of a young woman who struck her knee forcibly against a chair: "for part of two days she got about the house and up and down stairs, moving, however, with great difficulty and much pain," when an oblique fracture of the patella was detected.

Tillaux[4] mentions a source of error in the diagnosis of fracture of the patella, which, he says, he has several times witnessed: "An effusion of blood in the prepatellar bursa may give rise to crepitation, and the clots may even cause a sensation exactly like that of separation of the fragments." He is of opinion that this may have been the real state of things in some cases in which fracture has been supposed to exist, and in which it has been claimed that a perfect cure with bony union was effected. When there is doubt as to the existence of fracture, Mr. H. Morris recommends[5] "fixing the bone between the finger and thumb of one hand, and then pressing all around the circumference of it with the index finger of the other." Dupuytren[6] cites a case seen by Breschet, in which it was very difficult to determine the nature of an injury, sustained by a patella which had been fractured twelve years previously; the joint had become almost entirely anchylosed, and the conclusion arrived at was that the union had given way.

The *course* of these cases is very various, but that which is most usually observed is a gradual subsidence of the inflammation in and about the joint, and the formation of a ligamentous connection between the fragments. If there is no displacement, as occasionally happens by reason of the fibrous envelop and lateral ligaments remaining intact, this fibrous band may be exceedingly short, so that the fragments are very close together. But cases are upon record in which the separation, at first only slight, has been increased upon the use of the limb being resumed; and it is, I think, the rule that in every case some such increase takes place, unless the fragments have been united by bone. For bony union does sometimes occur; there are several specimens of it in the Mütter Museum of the College of Physicians of Philadelphia, and one is figured by Malgaigne; several are mentioned by Mr. H. Morris.[1] In such cases the usual rule obtains, that on the articular face of the bone there is rather a loss of substance than a deposit of callus, so that the line of fracture is marked by a shallow groove. T. C. Smith has recorded[2] a case of fracture of the patella by a fall on the knee, the outer condyle of the femur being also broken off. There was no separation; firm osseous union ensued in about six weeks, and no observable deformity was left from either fracture.

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[1] Diseases and Injuries of Bones, Syd. Soc. Transl., p. 225.

[2] Gaz. des Hôpitaux, 11 Août, 1881.

[3] Holmes's System of Surgery, 3d ed., vol. i. p. 1029.

[4] Op. cit., p. 1124.

[5] Loc. cit.

[6] Op. cit., p. 228.

Sometimes, as in a specimen figured by Morris,[3] it seems unquestionable that there has been a new formation of fibrous tissue, developed from a plasma, just as in some instances of like union between other bones; but this is not always the case, for there may be only an expansion of pre-existing ligamentous substance. When the fragments have been tilted, the attachment of these fibres may be somewhat changed, as in another example given by Morris.[4] Kirkbride[5] has reported a case in which the fragments had become united at their inner part by a round fibrous cord, the remainder of their extent being unconnected; with the knee in the straight position, they were two inches apart at the outer side and one and a half at the inner, while on flexion of the knee the distances were increased to three and three-fourths and two and a half inches. The patient had good use of the limb, and walked without any perceptible limp.

Irregular pressure by apparatus, or perhaps the unequal yielding of different portions of the ligamentous structures, may give rise to lateral tilting of the fragments, so that the gap between the latter is wider on one side than on the other. And sometimes there are irregular deposits of bone in the uniting medium, showing an effort at the establishment of bony union. Both these points are illustrated in a preparation in the museum of the Pennsylvania Hospital:[6] "The fracture has been transverse, about the middle of the bone; the fragments are covered by a thick membrane; a broad, fibrous layer, an inch and a quarter wide, unites the two fragments, being attached to their anterior surface. There is also a strong but thin band passing between their posterior surfaces. At the outer side of the patella there are two bony nodules springing from each fractured surface; these are evidently new-formed bone, and are almost in contact with each other, though no bony union has occurred between them; they were, however, firmly bound together by ligament. The degree of separation at the outside of the joint is not more than half an inch; at the inside it amounts to fully an inch." This specimen was taken from the body of an old negro, who had sustained the fracture eleven years previously.

Hamilton[7] makes the extraordinary statement that in the case of a young man of nineteen, with a transverse fracture caused apparently by a direct blow, 'the ligament subsequently gave way completely on the outside, and *a new patella formed* in the very much elongated ligament on the inner side."

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[1] Loc. cit.

[2] Am. Journal of the Med. Sciences, April, 1873.

[3] Loc. cit., p. 1031; fig. 175.

[4] Ibid., fig. 176.

[5] Amer. Journal of the Medical Sciences, May, 1835.

[6] Catalogue, p. 35; No. 1145.

[7] Treatise on Fractures, etc., 6th edition, p. 502.

It must be clear that in so far as the separation of the fragments is due to effusion within the joint, it must lessen as the fluid is absorbed; and this phenomenon has been strikingly described by Malgaigne, as noted by him in two of his own cases. But the contraction of the quadriceps muscle can only induce a progressive increase of the interval, and may thus act, if unopposed, for a long time.

Malgaigne says that the greatest separation within his knowledge was one observed by Sir A. Cooper, which amounted to four inches; but Cooper himself says,[1] "the bone may be drawn five inches upward, the capsular ligament and tendinous aponeurosis covering it being then greatly lacerated; and this, with one exception, is the greatest extent of separation which I have seen." And Morris[2] says that "in St. Thomas's Hospital Museum are two specimens in which the ligamentous union is six inches or more in length."

A curious shortening of the ligamentum patellæ sometimes occurs; and though it is not generally of great extent, yet it contributes somewhat to the ultimate amount of separation between the fragments. Perhaps this is due in some degree to pressure by apparatus, which certainly often has the effect of causing the gap to be greater at the anterior surface than at the posterior. Callender[3] has noted the occasional occurrence of hypertrophy of the fragments, as well as the fact that the opposite condition has been met with, the broken portions becoming atrophied. He also mentions a specimen, in the museum of the Middlesex Hospital, in which the lower fragment has become united by bone to the tibia, so that the fibrous band between the fragments had come to represent the ligamentum patellæ.

In one or two recorded instances, the upper fragment has contracted adhesions to the femoral condyles, but without any direct influence in impairing the usefulness of the limb.

Refracture of the patella is not a very unfrequent occurrence. Sometimes, but rarely, the bond of union gives way. More frequently the bone separates at another point; and this, I think, is to be accounted for on the ground that as the use of the limb is acquired, one or other of the fragments comes to bear, as the original bone did, over the lower extremity of the femur, this portion then giving way under a "cross-breaking strain." I have myself reported[4] a case in which, under the use of Malgaigne's hooks, I had succeeded in getting extremely close union of a transverse fracture, and the bone gave way, apparently at the same point, four months afterward, under a sudden slight strain. But instances of this kind are not common. Little[5] has recorded a case in which, ligamentous union having occurred, a second fracture, half an inch higher up, took place nine months afterward; so that when the patient finally recovered, there were three fragments and two clearly defined fibrous bands. Parson[6] published an account of a case in which (in December, 1874) the left patella was fractured at the junction of the middle and upper third; in October, 1880, the same bone gave way at the junction of the middle and lower thirds, and in August, 1882, it was again broken at the same point. Lloyd[7] saw a patella broken by direct violence, which gave way again twice at intervals of twelve months. Bryant mentions a case seen by him, in which one patella had been broken twice, and the other three times.

It is not very difficult to see why fracture of one patella should occasion ally be followed by a like misfortune to the other. The patient will naturally spare the limb which has already suffered, and in case of a slip, or any demand for effort, will be likely to put a severe stress upon the better one, which yields as its fellow did. The interval between the fractures is sometimes a long one. I have now under treatment at the Episcopal Hospital a robust and healthy man with fracture of the right patella, in whom the bone of the left side was broken about two years ago, and is united by a short fibrous bond. He was not aware of any lameness or weakness of either limb.

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[1] Dislocations and Fractures of the Joints, p. 224.

[2] Loc. cit., p. 1030.

[3] St. Bartholomew's Hospital Reports, 1870, p. 49.

[4] Am. Journal of the Med. Sciences, Oct. 1861.

[5] Med. Record, March 4, 1882.

[6] Lancet, May 19, 1883.

[7] Birmingham Medical Review, March, 1883.

When refracture occurs, the damage done is sometimes far more serious than that of the original accident. Thus King[1] met with a case in which, five months after a fracture of the patella, union having taken place with the fragments about half an inch apart, the whole knee was burst open, a wound seven inches long being produced, and the fragments separated an inch and a quarter. Suppuration ensued, but the patient made a good recovery; the amount of motion in the knee, if any, is not stated.

Charles Bell[2] mentions a very similar instance. "The bone had united by ligament, and this ligament had incorporated with the skin in such a manner that it lost much of its pliancy. The poor man was carrying a burden and fell backward, the knee sank under him, and the whole forepart of the joint was laid open by laceration. The case terminated in amputation of the limb." Malgaigne, after referring to this case, says: "I have seen a nearly similar instance; the rupture of the fibrous band was attended with enormous ecchymosis, gangrene ensued at about the fifth day, and death closed the scene. M. Seutin quite recently sought in vain to save a limb thus affected; after four months of suffering, amputation of the thigh became the only resource."

Thomson[3] reported to the surgical section of the British Medical Association, a case of old fracture of the patella, in which suture of the fragments had been practised; a year later, the knee being stiff, the patient tripped, and burst open the whole joint. Resection was performed, with a good result. He refers to other like cases seen by Bell, Poland, and Pelletan, in all of which amputation was deemed necessary. A very similar instance has been placed on record by Mason,[4] and another, but with a far more fortunate issue, by Roberts.[5]

Necrosis of a portion of the fractured bone has been observed in a very few instances. One of these is given by Erichsen,[6] as follows: "The patient, a middle-aged man, had met with an ordinary transverse fracture of the patella, which united by ligament two years after the accident; and without any fresh injury he came to the hospital, with necrosis of the outer half of the upper fragment, which was completely detached, and lying in a cavity bounded and shut off from the joint by plastic matter. I cut down upon and removed the necrosed fragment, which appeared to constitute about one-quarter of the patella. No cause could be assigned for the necrosis, except defective vascular supply to this part of the bone." Another instance is briefly referred to by Lawson,[7] "in which a portion of the patella was chipped off, necrosed, and fell into the joint, there setting up inflammation, which caused death." Hulke[8] says that a partially detached portion of one of the fragments may die and be gradually exfoliated, as in Liston's patient, a sailor, aged twenty-four, who died seven weeks after the injury from hectic fever following extensive suppuration in and around the knee-joint.

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[1] Dublin Med. Press, Dec. 8, 1847.

[2] A System of Operative Surgery, 2d Am. ed., vol. ii. p. 361. 1816.

[3] British Med. Journal, Aug. 26, 1882.

[4] Med. Record, March 20, 1875.

[5] Bryant's Surgery, 3d Am. ed.

[6] Science and Art of Surgery, Am. ed., vol. i. p. 381. 1873.

[7] British Med. Journal, June 9, 1877.

[8] Holmes's System of Surgery, 3d ed., vol. i. p. 1028.

A fact of much importance, as will be seen when the subject of treatment comes under discussion, is that the usefulness of the limb after recovery from fracture of the patella is not necessarily in proportion to the closeness of apposition of the fragments. I have seen a number of persons who had had this injury, and in whom very great separation remained, who yet were able to walk, to go up and down stairs, and even to mount, as for instance into a chair, as well apparently as ever. One very large and portly man, well known for years in Philadelphia, had had fracture of both patellæ at different times, with very lengthy ligamentous union, and yet he walked about freely, and showed no peculiarity of gait beyond what might have been perfectly natural to him.

Such, however, is not always the case. Callender[1] says: I note in April, 1866, the case of a poor fellow who had fractured either patella some years previously, and who was admitted for some other trouble. He had lost all power of recovering himself when the body was bent back from the knees, and thus he constantly fell whilst moving about. In his case the interval between the two fragments of bone on each side was less than two inches and a half, but then both knees were damaged." My belief is that much depends upon the confidence felt by the patient; and it is very probable that in a case of simultaneous fracture of both bones, the loss of power would be apt to be greater and more persistent than if the injury should be sustained first in one limb, and at some later period in the other.

When fracture of one patella has taken place, and even when, as in an instance recorded by Hamilton,[2] the fragments are separated to a distance of four and a half inches, and no bond of union can be detected, the rule is that in a greater or less length of time, with judicious management, the strength and usefulness of the limb are in a very complete measure regained. Hence it seems to me that the *prognosis* of these cases may be favorable, so far as the ultimate result is concerned; but the patient should not be led to think that his recovery will be speedy, not only lest he should be disappointed, but also lest he should by imprudence sustain further damage.

As to the *treatment*, a great deal of ingenuity has been expended in the endeavor to devise means of holding the fragments in apposition, or as nearly so as possible; and a vast number of appliances for this purpose, many of them very similar in principle, and varying only in trifling details, have been described, each with its inventor's name. I shall not attempt to give a complete list of these, but propose to state the objects to be aimed at, and the chief methods by which they may be attained; not omitting any practical suggestions, but not being careful to mention all the curious and complicated mechanisms which have been from time to time recommended, without acquiring more than a transient and local reputation.

Surgeons have differed as to the best position in which to place the limb, some advocating the flexion of the hip-joint, others deeming it of little importance. Callender[3] says: "I hope the old fashioned plan of raising the limb on an inclined plane for the treatment of fracture of the patella is quite obsolete. Fractures of this sesamoid bone are now treated in St. Bartholomew's by rest simply, the limb lying in the horizontal position." On the other hand, Mr. Croly, of Dublin, is said[4] to be "content to obtain good fibrous union by simply elevating the limb, so that a line drawn from the toe will pass on a level with the patient's nose, the chest and shoulders being raised by a bed-rest, and subduing all inflammation by ice and evaporating lotions."

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[1] Loc. cit., p. 49.

[2] Op. cit., 6th ed., p. 527. 1880.

[3] Loc. cit., p. 48.

[4] Lancet (editorial), March 31, 1883.

While it is very probable that the importance of flexing the limb strongly upon the body may have been overstated by some writers, it seems to me that surgeons generally would be unwilling to forego the advantage gained by complete relaxation of the muscles on the front of the thigh. But in order to secure this, it is not necessary to place the limb at an angle of less than about 130° with the axis of the body. It is, however, essential that the knee should be kept in the extended position, and this becomes very irksome from stretching of the posterior muscles, if the hip-joint is strongly flexed. So generally has the propriety of this posture of the knee been recognized, that almost all surgeons have included a back-splint in their appliances for dealing with fractures of the patella. By some the ordinary single-inclined plane is used, so arranged that the degree of elevation of the foot may be altered at the will of the attendant. Others have employed a trough of tin, gutta percha, binders' board, or some like material; while many prefer a board, either sloped off above and below, or padded, so as to fill up the hollow of the ham. If such a board is used, it should be of suitable width for each portion of the limb, very slightly hollowed out along the middle, and at its ends the edges should be carefully bevelled off so as to make no pressure upon the skin.

Plaster-of-Paris bandages have been used by some surgeons, and the starched bandage is highly recommended by Erichsen; but neither of these can, in my opinion, be safely employed, except in the later period, when the patient is beginning to weary of confinement, and union has so far progressed as to be in a measure assured. Hamilton quotes several cases in which the injudicious use of plaster of Paris, or of a silicate bandage, seemed to be the clearly assignable cause of very imperfect results, and one has been recorded[1] in which gangrene ensued, and amputation had to be performed.

I will merely mention that some surgeons on the Continent of Europe have resorted to what must, I think, be regarded as an unjustifiable practice—the aspiration of the knee-joint for the removal of the effused liquid, by which it is apt to be distended for a few days after the accident. Such interference is not only theoretically attended with risk, but it has been actually proved so. I do not refer to the rare cases in which a formidable arthritis has already been set up, and in which there is an existing danger from the products of inflammation within the joint, although as to even these there are conservative surgeons who would hesitate to adopt such measures; but to those cases in which the effusion is a mere temporary inconvenience, and in which nature will do the work of relief as surely and much more safely, if not as promptly, as any surgical instrument.

For a few days, then, until the swelling of the joint has subsided, the best course is to place the limb at rest on a back-splint, and to employ suitable means for allaying the local irritation. Evaporating lotions, lead-water and laudanum, or hot water-dressing, may be made use of, the choice being determined according to the age and strength of the patient, the season of the year, and perhaps other circumstances.

Upon the disappearance of the effusion into the joint, means must be adopted for approximating the fragments. Should the tendency to separation be very great, an attempt should be made to control it even from the outset; for although the bringing of the fragments together may be impossible, and even inadvisable for fear of injury to the joint, yet the subsequent coaptation may be rendered easier. The best way of doing this is by means of a compress of folded lint, having around it an envelope of adhesive plaster, the adhesive surface outside; this being placed on the skin just above the upper fragment, and the middle of a strip of bandage laid over it, the ends of the bandage may be gently drawn upon, and secured to pegs or nails at either side of the splint, at such points that the tension shall be exactly in the direction desired.

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[1] Am. Journal of the Med. Sciences, Feb. 1840; from the Gaz. Médicale, 1839, No. 28.

The aim of most of the inventors of appliances for the treatment of these fractures has been to act on both fragments, forcing them together. But, in fact, the lower one is not displaced, unless by the shortening of the ligamentum patellæ, before spoken of; and it is very doubtful whether this is not actually promoted by pressure brought to bear upon it in some methods.

Various devices for circular pressure were used at a very early date; Malgaigne speaks of splints perforated in the centre, and kept in place by a bandage (the patella being received into the opening, by the edges of which the fragments were held together), as known to Albucasis, Guy de Chauliac, and others. This plan, he says, was still employed at the Hôtel Dieu in the latter part of the last century.

Another development of the same idea was the ring or cap, which has been revived in modern times by Knight,[1] Gibson,[2] Eve,[3] Blackman,[4] and perhaps others. Its simplicity is its only recommendation, and although it may answer well where there is little or no gap between the fragments, and where mere support is required, it is not likely to take the place of appliances which admit of greater adaptation to the circumstances of each case. A positive objection may be made to it on the ground of its interfering with the nutrition of the bone. Gross[5] quotes Manning as having "observed by dissection that the vascular arch of the upper fragment is situated at the precise spot where the greatest amount of pressure is usually made by the retentive apparatus; and that the lower fragment experiences a similar fate when, as not unfrequently happens, the internal superior and inferior arteries arise from a common trunk." By Thomas,[6] also, the importance of non-interference with the circulation of the patella is urged.

By a great many surgeons, the use of pressure by bands, with or without compresses, and arranged in various ways, has been relied upon. Thus Dorsey used a back-splint, with tapes fastened to it, which were brought up above and below the broken bone, so that they should draw the fragments into place; the lower one passing above, and the upper one below, crossing one another at each side. A somewhat similar arrangement, but with pegs for tightening the bands, is recommended by Agnew.[7] Perhaps it need hardly be pointed out that by changing the points of attachment of the tapes or bands, the traction may be brought more or less parallel with the long axis of the limb; and that the further apart they are, the more directly will the fragments be drawn together. Hamilton uses a moulded trough, and figure-of-8 turns of a roller. Sir A. Cooper laid tapes along the limb on either side of the fractured patella, and then applied a roller, leaving the patella uncovered. By drawing up the ends of the tapes, and tying the corresponding ones together, the turns of the roller above and below the knee were approximated, and with them the fragments. The obvious objection to this plan is the circular constriction which it of necessity involves. Gerdy's method was somewhat similar to this. A much better device, but still subject to the same inconvenience, was afterward used by Cooper;[8] it was a leathern band buckled round the thigh just above the patella, and drawn down by another strap passing down from it, around the sole of the foot, and then up along the other side of the leg. An apparatus, very similar in principle, has lately been proposed by Levis, of Philadelphia.[1]

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[1] Am. Journal of the Med. Sciences, July, 1860.

[2] St. Louis Med. and Surg. Journal, Oct. 1866. This author claims to have obtained bony union by means of the ring.

[3] Nashville Journal of Medicine and Surgery, Feb. 1867.

[4] Western Journal of Medicine, May, 1868.

[5] Op. cit., vol. i. p. 999.

[6] Med. Press. and Circular, Oct. 11, 1882.

[7] Op. cit., vol. i. p. 974.

[8] Op. cit., p. 229.

A plan which has in my hands proved very satisfactory, is known as Sanborn's. Its peculiarity consists in the use of a strip of adhesive plaster along the upper surface of the limb, leaving a free loop just over the patella. Compresses having been applied, and the ends of the strip secured by transverse strips and a roller, the loop is twisted up by means of a bit of stick passed through it, until the compresses are so drawn together as to bring the fractured surfaces as nearly as possible into contact. The stick is then secured by tying its ends with a strip of bandage passed round under the back-splint. Of course the pressure can be increased at any time by twisting the loop up tighter, and can be lessened by untwisting it.

A number of appliances have been proposed, and a few of them have been extensively used, with semicircular or crescentic plates of metal, arranged to press against the upper and lower edges of the fragments, and to push them together. Of these, Lonsdale's[2] was the first; his plates were carried on arms attached to the back-splint, and by means of screws and nuts could be adjusted so as to produce the desired effect. I need hardly enumerate the other forms of apparatus based upon this idea, as they can be found described in readily accessible works, and have mostly had but an extremely limited use. Some of them are complicated, and others inefficient.

Perhaps I may be permitted here to digress for a moment, and to say that this subject of the treatment of fractures of the patella affords a striking illustration of the fact that in surgical appliances and methods what is wanted is not power, not mere brute force, but exact adaptation. Much ingenuity has been expended upon the invention of apparatus to overcome resistance which it is far better to evade than to oppose, to coax than to compel.

An apparatus employed at the Middlesex Hospital,[3] in London, seems to me to possess very great advantages, and I will quote the description of it in full:—

> "A broad piece of moleskin plaster, cut out at one border, somewhat horseshoe-shaped, but with the ends of the curve prolonged, is fixed to the thigh, so that the curved edge is level with the normal position of the patella, and is retained by means of a few turns of roller. Next the limb is fixed upon a well-padded McIntyre or simple wooden back-splint having a foot-piece. Then the lower fragment of the patella is fixed by means of a pad of lint and broad strip of adhesive plaster applied figure-of-8 fashion around limb and splint; and the bandage which confines the foot and leg to the splint is continued upward as far as this pad, which it assists in fixing. To the prolonged ends of the moleskin plaster are sewn pieces of bandage (pieces of moleskin plaster of different sizes cut to the right shape, and having the pieces of bandage fastened on, are always kept ready) which are attached in turn to India-rubber accumulators, one on each side of the leg; each of the accumulators at its lower end is fastened to a piece of bandage, and these are tied together below the foot-board of the splint. With a pad of lint at the upper border of the superior fragment of the patella beneath the free edge of the moleskin, the requisite amount of tension is obtained by tightening the tied pieces of bandage."

I am at present using this plan in two cases in my wards at the Episcopal Hospital, and find it satisfactory.

A very elegant, but very complicated arrangement for the use of weights and pulleys in coaptating the fragments of the broken patella, the invention of which is ascribed to Dr. Burge, of Brooklyn, is figured by Agnew. Callender,[1] Hornibrook,[2] and Grant[3] have suggested simpler devices for merely drawing down the upper fragment by means of a weight and pulley. I think that instruments of this kind would scarcely be available in practice, unless with extremely tractable patients.

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[1] Agnew, op. cit., vol. i. 980.

[2] Treatise on Fractures, p. 427.

[3] Holmes's System of Surgery, 3d ed., vol. i. p. 1032.

Malgaigne's hooks, intended to act directly upon the bone itself, and to keep the fragments in exact apposition, have been by some surgeons regarded with great favor, while by others they have been strongly condemned. The instrument, as used by its inventor and by others, myself among the number, consisted of a pair of steel plates, each carrying a pair of strong recurved hooks, and having on its upper face a block perforated with a female screw; the hooks having been inserted through the skin so as to catch, one the upper edge of the upper fragment, the other the lower border of the lower one, were brought toward one another by turning a male screw through the blocks, and the fractured surfaces were thus forced together. Within a few years, Morton and Levis[4] have employed these hooks, detaching them so as to make them into two independent pairs, or into a set of four movable hooks. The question with regard to them, however, is not of their efficiency, which is obvious, the modifications suggested being merely for convenience in application; it is whether their use is or is not attended with danger. On this point Agnew[5] says:—

> "Once have I seen death follow the use of this infernal machine, from an erysipelatous inflammation extending into the joint, and giving rise to abscesses, both within and without the articulation. No advantage whatever results from the close contact of the fragments accomplished by the instrument; it is rather a disadvantage, as the tendency to refracture is increased by the very closeness of the union, the intermediate bond not being as strong as the ordinary fibrous tissue which fills the gap when the pieces of the bone are a short distance apart. Three times have I seen the union broken a few weeks after the patients treated by this method had been discharged from the hospital."

Hamilton[6] quotes from Volkmann: "That Malgaigne's hooks have caused ulceration of the joint and death of the patient in a number of cases, is only too true; I, myself, know of two which occurred in the practice of friends, and which were never published, and another sad experience was met with in my own clinic a number of years since." On the other hand, De Morgan,[7] speaking from his experience with the hooks in the Middlesex Hospital, says "there is no method of treatment which, with so little trouble to the surgeon or irksomeness to the patient, will produce such satisfactory results."

Hamilton, while he says that "several cases have been reported of dangerous or disastrous inflammation induced by the hooks," thinks that "in cases in which the original separation exceeds one or one and a half inches, and especially in cases of a refracture or rupture of the fibrous band, accompanied with great separation," the plan is entitled to a further trial.

In the case recorded by me,[8] in which the hooks were used, they caused no inflammation of any moment, and by experiment on the dead subject I afterwards satisfied myself that there could be no risk, with ordinary care and skill, of wounding the knee-joint in their application. With the exception of the cases referred to by Agnew and Volkmann, and one reported by

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[1] Practitioner, March, 1875.

[2] Canada Lancet, Jan. 1876.

[3] Edinburgh Med. Journal, Oct. 1876.

[4] Medical News, Jan. 7, 1882. See, also, Surgery in the Pennsylvania Hospital, p. 274.

[5] Op. cit., vol. i. p. 980.

[6] Clinical Lecture, Med. News and Abstract, April, 1881.

[7] British Med. Journal, May 24, 1842.

[8] American Journal of the Medical Sciences, April and October, 1861.

Mr. Royes Bell,[1] I do not know of any distinct statement of damage done by this plan of treatment; and if the obtaining of very close apposition of the fragments were the only condition of restoring the usefulness of the limb, I should regard the employment of the hooks as not only justifiable, but an imperative duty. Such, however, is not the case; very many patients, as has been before stated, are able to walk, climb, and run, with the fragments connected by fibrous bands of considerable length; and it seems to me that the question is, therefore, one which may be left to the individual judgment of each surgeon. Those who use the instrument are not to be adjudged foolhardy, and those who abstain from employing it are not necessarily timid or over-cautious.

Trélat is said by Stimson[2] to have applied the hooks through the medium of plates of gutta-percha, moulded to the anterior aspect of the limb above and below the knee; thus avoiding the wounding of the skin, and, of course, placing the joint beyond all risk of harm. Similar plans have been advocated by Spence[3] and by Gant.[4] But whether the instrument is not deprived of its efficiency by this change, may be seriously questioned.

Of late years, even bolder procedures have been advocated and practised, with a view to securing apposition of the fragments in transverse fractures of the patella. Operations similar to those mentioned in the early part of this article[5] as performed in cases of non-union of other bones, the exposure and wiring together of the broken portions, have been resorted to, and in many cases with success, notwithstanding the unavoidable risks from the neighborhood of so large a joint as that of the knee. The idea is not altogether a new one. Hamilton[6] says: "Severinus, an Italian, proposed to make an incision into the joint, exposing the fragments, and then to freshen the broken surfaces and bring them together. This was nearly three hundred years ago, when surgeons did not pretend to have any specific for preventing inflammation after wounds of large joints, such as Mr. Lister thinks we possess to-day." Malgaigne also refers to this proposal, but only to condemn it. According to Byrd,[7] Dr. George McClellan, of Philadelphia, adopted such a course many years ago, in one instance, and as an experiment, which is said to have proved successful; but no account of this case was ever published, and it certainly seems as if more would have been known of so bold a procedure, and as if the surgeon would have had imitators, if the result had been favorable. It was also among the achievements of Prof. Cooper,[8] of San Francisco.

As has been before remarked, the gravity of fractures of the patella depends in no small degree upon the involvement of the knee-joint; and the same may be said of these operations. By the advocates of Listerism, it is claimed that "antiseptic precautions" diminish the risk of opening the joint-cavity.[9] Rose[10] reported to the Medical Society of London, two cases of fracture of the patella in which he opened the knee-joint, drilled the fragments, and fastened them together with silver wire. The operations were done with antiseptic precautions; no bad symptoms ensued, and the final result in each case was satisfactory.

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[1] Lancet, April 29, 1882.

[2] Op. cit., p. 561.

[3] Practitioner, March, 1875; Med. Times and Gazette, Aug. 21, 1875.

[4] Lancet, April 29, 1882.

[5] See pp. 62 *et seq.*

[6] Clinical Lecture in the Med. News and Abstract, April, 1881.

[7] New York Medical Journal, May, 1876.

[8] As claimed in a letter from him, quoted in the Medical Times and Gazette, Nov. 2, 1861. The original report I have been unable to find.

[9] Lister himself is reported (Lancet, Nov. 22, 1879) to have said that "the risk a patient incurs in having his knee-joint opened antiseptically is not greater or so great as that attending the removal of an ordinary fatty tumor without antiseptic treatment." I have no hesitation in saying that such a claim is unsupported by the experience of the profession at large. Perhaps I may say here that there is often a confusion between safety and impunity. The fact that an operation has been done with success, does not by any means show that it did not involve great risk. Persons have fallen from great heights, sustaining only slight injuries; but they certainly were in most imminent danger.

[10] Lancet, Jan. 22, 1879.

Cameron[1] gives the case of a man, aged thirty-five, in whom the broken patella had formed a wide ligamentous union, the fragments being, in extension of the knee, three inches apart, and in flexion admitting the breadth of the hand between them; he sutured them with thick silver wire, under antiseptic precautions, leaving a drainage tube in the joint. The result was satisfactory; eight months afterward the man had difficulty in flexing the knee, owing to the shortening of the parts in front.[2]

Other instances have been recorded, without a distinct statement as to the fact of interference with the joint. Thus Barling[3] showed to the Midland Medical Society "an adult patient who by a fall had torn the ligamentous union of an old fractured patella. By a longitudinal incision over the bone, the fragments had been laid bare, refreshed, and then approximated by a single silver wire suture, which was cut off short and left. The operation had been performed some weeks before, and the fragments were in good position. In course of time, Dr. Barling hoped that solid osseous union would take place." Holmes[4] records the history of an attempt to obtain bony union in a case in which the fragments were connected by fibrous tissue; an incision was made with antiseptic precautions, and a suture applied; the patient's life was seriously endangered by suppurative inflammation.

Other cases have been reported in various journals.[5] One instance in which very little good seems to have been accomplished is recorded by Lloyd.[6] The fracture was caused by direct violence; the knee gave way about twelve months afterward, and again twelve months after that. Malgaigne's hooks were then used, but without success, and incision, resection, and suture were employed, with division of the quadriceps tendon, of the tissues at either side of the bone, and of the ligamentum patellæ. The suture was allowed to remain; the fracture, however, was still ununited.

Lund[7] has proposed a plan of treatment combining the idea of Malgaigne's hooks and that of suture of the fragments. He advocates keeping the limb extended, on a back-splint with a foot-piece, and slightly raised; a cold evaporating lotion, or ice, is applied to the knee until nearly all effusion has subsided. Then, under anæsthesia, a strong screw-pin is driven into each fragment so as not to injure the articular face, and a double-acting screw-instrument is applied so as to bring the fragments together. Then a coil of very thin copper wire is firmly wound around the pins, and the screw-instrument is removed.

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[1] Glasgow Medical Journal, April, 1883.

[2] In the Index Medicus for August, 1883, I find the following title: Henzelt, Ueber die Behandlung der subcutanen Querfracturen der Patella mit besonderer Berücksichtigung der Punction des Gelenkes und der Knochennaht. Dorpat, 1883. (On the treatment of simple transverse fractures of the patella, with reference especially to puncture of the joint and suture of the bone.) The work itself I have not seen.

[3] British Med. Journal, April 14, 1883.

[4] St. George's Hospital Reports, 1879.

[5] Ward (British Med. Journal, June 9, 1883) records five operated on in the Leeds Infirmary, three having been cases of simple and two of compound fracture. I find also in the Index Medicus the following:—

Weinlechner, Eine durch Verschüttetwerden erzeugte Fraktur der Patella, welche das Gehen wegen weiten Abstandes der Bruchstücke und unwollständiger Streckung des Unterschenkels behinderte, kam nach sechsmonatlichem Bestande durch Resection und Naht der Bruchstücke zur Heilung mit normaler Function. (A fracture of the patella by direct violence which hindered walking by reason of the wide separation of the fragments and inability to extend the leg; after six months the normal function was restored by resection and suture of the fragments.) Aertzl. Bericht der k. k. allgem. Krankenh. zu Wien, 1882.

Sacré, Fracture ancienne de la rotule droite; avivement; suture osseuse; guérison avec ankylose. (Old fracture of the right patella; freshening of edges; suture of the bone; cure with anchylosis.) Journal de Médecine, Chirurgie et Pharmacie, Bruxelles, 1883.

Wahl, Naht einer Patella-fraktur. (Suture of a fracture of the patella.) Deutsche med. Wochenschrift, Berlin, 1883.

[6] Birmingham Medical Review, March, 1883.

[7] Lancet, April 29, 1882.

Occasionally, very bad results have followed these heroic measures. Wyeth[1] relates a case of long standing in which the fragments were sutured; the joint suppurated, and amputation became necessary.

It has been proposed by Ollier, Wyeth,[2] and others, to insert fresh marrow cells between the fragments; and the plan has been adopted in a few instances, but I believe with only negative results. The theory of such a procedure is difficult to understand; it would seem to be needless if the fragments were close together, and useless if they were widely separated, to say nothing of the want of a physiological ground for expecting any advantage from it in the way of bone-formation.

Dieffenbach[3] made a subcutaneous section of the ligamentum patellæ, and of the rectus femoris about three inches above the patella; he then rubbed the fragments together, and kept them in contact by means of an apparatus for parallel pressure; it is said that there was "complete hardening of the interposed substance," and that the patient's condition was markedly improved. One cannot help asking, however, whether the mere solidification of the patella would not be somewhat dearly bought at the expense of a lengthened and weakened ligament, and a muscle impaired by the substitution of a cicatrix for a portion of its substance.

It will now be necessary, in order that the reader may not be only embarrassed by the foregoing enumeration of methods and appliances for the treatment of fractures of the patella,[4] that I should give a brief and practical summary of the subject. Here, as elsewhere, the great aim of the surgeon is, and ought to be, to restore, as nearly as possible, the normal state of things; and it has, therefore, been thought desirable to obtain bony union between the fragments. But that this is not essential to a good cure has been shown in the facts stated as to the value of limbs in which the fragments were connected only by a fibrous band of considerable length. Hence it may well be questioned whether it is not a mistake to concentrate all our attention upon merely forcing the fragments together, and especially to run any risk of doing greater mischief by the very means employed to this end.

Whenever the fragments have already been forced apart, a tearing of the fibrous tissues surrounding the bone, and in the neighborhood, must have occurred. To prevent any increase of this rending, by properly securing the upper portion of the bone, is manifestly indicated; and in doing this it is equally clear that interference with the nutrition of the bone and of the limb should be avoided. I think that it is sound surgery to use mild means first; and hence should advise the relaxation of the quadriceps muscle by extending the knee, and flexing the hip-joint by elevating the foot. As soon as the inflammatory symptoms of the first few days have been subdued, the upper fragment should be brought down, but not with any great force, and a compress applied above it, with pressure in such a direction as to oppose the upward pull of the quadriceps muscle. For this purpose any of the simpler means above described will answer; I think that the elastic traction of the Middlesex-Hospital plan is perhaps the best, but it should not be too vigorously applied. At the end of six or seven weeks, it will be found that the tendency to separation of the fragments no longer exists, and the patient may be allowed to lie in bed with merely a back splint on the knee, and with the limb otherwise unconfined. A week later he may be permitted to sit up, and to move about in a wheel-chair; after which the use of the limb may be gradually resumed, the back splint being left off. It may very probably be that the uniting medium will be found to stretch, and the gap between the fragments to be thus widened; but in time the parts will acquire firmness, and the result will be satisfactory.

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[1] Med. Record, June 22, 1882.

[2] Ibid., May 11, 1878.

[3] Casper's Wochenschrift, Oct. 2, 1841.

[4] The list might have been still further extended, but I have not thought it worth while to include a number of contrivances, which, although published as new, are really only modifications, and often very trifling ones, of existing plans or instruments.

In the rare instances in which this does not happen, but the limb remains weak and useless, the propriety of resorting to more energetic means may be considered. I do not myself think that any great risk is run in using Malgaigne's hooks, but I do not think that any great gain is effected by them. And, although much is claimed for the graver procedures, the resection and suture of the fragments, I think that a faithful trial should first be made of the reparative powers of nature, aided by frictions, shampooing, and well-regulated exercise, before the patient is subjected to the hazards which they cannot but involve. Everything else failing, and it being clear that the want of union between the fragments is the sole cause of the disability, extreme measures may be taken; but the patient should be made fully aware of the extent of the dangers attending them, and of the chances of anchylosis, or of still worse evils.

As to section of the quadriceps or its tendon, it seems to me to be merely the substitution of one evil for another. If incomplete, it is useless, while, if complete, it must almost of necessity involve the wounding of the knee-joint.

Compound fractures of the patella are always of grave importance, largely increased if the knee-joint be directly involved. These injuries are always due to direct violence, and the bone is often comminuted. The arthritis which is so apt to ensue upon simple fractures may be looked for in even a higher degree in the cases in question, and is much more likely to assume the suppurative character, as it will almost certainly do if the synovial cavity is laid open to any extent. Gross[1] mentions a case followed by abscess, necrosis, and removal of the patella, the knee-joint becoming partially anchylosed. Levergood[2] records an instance in which, the patient having been inefficiently treated, and having left his bed four weeks after the accident, suppurative arthritis ensued, and the joint was emptied by incision; amputation was proposed but refused; recovery took place, and the patient was dismissed with "slight anchylosis." Poland,[3] among 85 recorded cases, found that 20 proved fatal; suppuration occurred in 63, and anchylosis more or less complete resulted in 31 out of the 65 in which recovery took place.

The *symptoms* are generally sufficiently clear. The *diagnosis* is only obscure, in some instances, in regard to the involvement of the knee-joint, which may be but slightly punctured; sometimes the opening is large enough for the finger to be readily passed in, and in any case the escape of synovia, if abundant enough to be distinctly perceived, is conclusive.

The *prognosis*, it need hardly be said, is to be carefully guarded. If the immediate danger of shock is surmounted, there remain too many chances against both the limb and the life of the patient to warrant the surgeon in presuming upon success. Yet it does sometimes happen that complete recovery takes place, even under apparently adverse circumstances.

The *treatment* is not materially different from that of ordinary simple fractures, except that the wound must be dressed. If small, an attempt may be made to close it; but if large, and if the joint-cavity be opened, I think that thorough washing out with carbolized water should always be resorted to. Afterward, the closure of the wound ought again to be aimed at, as it may be obtained unless suppuration ensue, in which case experience teaches that effective drainage gives the best results; this may be accomplished either with a fine rubber-tube, with horse-hair, or with a few strands of carbolized silk.

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[1] Op. cit., vol. i. p. 1004.

[2] Am. Journal of the Med. Sciences, Jan. 1860.

[3] Med.-Chir. Transactions, vol. liii.

As dressings, lead-water and laudanum, carbolized water, or an ice-bag (in hot weather especially) may be employed. Irrigation has been preferred by some surgeons, but cannot always be conveniently arranged so as not to wet the clothing and bed, on account of the position of the limb.

The question of amputation or of excision of the joint must sometimes come up when the patient is young, and the local injury very severe, but it can hardly be appropriately discussed here.

Perhaps it is in these cases that the use of Malgaigne's hooks, or the resort to the suture, is most available; yet I cannot but think that other means should first be tried, and that they will often be found efficient.

Very generally, after the first stage of the case, and especially if suppuration is established, a stimulant and supporting treatment is obviously demanded, and must be kept up during a long and tedious convalescence.

Fractures of the Bones of the Leg.

All authors agree that these injuries are of very common occurrence; but there are some curious differences noticeable between the statistics derived from different sources, as will appear from the following data, chiefly obtained from Gurlt:—

Lonsdale, out of 1901 cases, gives 289, or about 15 per cent. of the leg.
Gurlt, among 1631, found 283, or over 17 per cent.
Blasius, out of 778, found 139, or nearly 18 per cent.
Middeldorpf, out of 325, gives 59, or a little over 18 per cent.
Matiejowsky, among 1086, gives 293, or nearly 27 per cent.
Agnew, among 8667, found 2315, or nearly 27 per cent.
Malgaigne, out of 2328, found 652, or 28 per cent.
Lente, among 1722, gives 579, or nearly 34 per cent.

If the reader will take the trouble to compare these statements with those quoted on page 186 from the same sources, but in reference to fractures of the femur, he will see that the figures given by the different institutions, for the latter bone, are not in the same ratio to one another as those above quoted for the leg. But these discrepancies can only be stated as facts, difficult, it seems to me, of explanation.

Fractures of the leg are divided into those which affect both bones, those of the tibia alone, and those of the fibula alone. These again are found to differ in frequency; both bones being involved far oftener than either bone singly. These differences are marked enough to warrant their presentation in a table as follows:[1]—

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[1] The percentages in this table have reference to the fractures of the leg only, and in stating them they are given approximately, neglecting fractions.

	Both bones.	Tibia alone.	Fibula alone.
Lonsdale	197 or 68 per cent.	41 or 14 per cent.	51 or 17 per cent.
Gurlt[1]	173 " 61 "	36 " 13 "	42 " 15 "
Blasius	94 " 67 "	30 " 21 "	15 " 11 "
Middeldorpf[1] . .	40 " 68 "	8 " 14 "	9 " 15 "
Matiejowsky . .	230 " 78 "	33 " 11 "	30 " 10 "
Agnew	1441 " 61 "	437 " 19 "	437 " 19 "
Malgaigne . . .	515 " 79 "	29 " 4 "	108 " 15 "
Lente	442 " 73 "	45 " 8 "	92 " 16 "

Among the 316 cases derived by me from the records of seven years at the Children's Hospital, there are stated to have been 7, or a little over 2 per cent., of the leg; they are not classed as above, but fractures of either bone by itself are of extreme rarity during childhood, as, indeed, may almost be said of fractures in this region in general. Probably the reason of this may be found in the very slight leverage afforded by the bones of the leg at this period of life, whereas the femur, which is so often broken in children, yields by reason of its slenderness. I have, however, myself repeatedly had occasion to treat fractures of the leg in children in private practice.

It may easily be seen why the proportion of fractures of both bones should be so large. Any force applied to the part, sufficient to break one bone, will be likely to act on both; and if one of the bones gives way, the other, losing its support, will be very apt to give way also.

Fracture of the leg may occur at any age, and in either sex; but the great majority of its subjects are adult males, simply because these are especially exposed to the violence by which the injury is produced. Agnew says that he has twice seen intra-uterine fracture of both bones; and two other cases have been referred to elsewhere.[2] On the other hand, Meachem[3] has reported the case of a woman aged ninety years, who broke her leg in the lower third; union had occurred by the twenty-eighth day.

For greater convenience, fractures of both bones of the leg will first be considered, then those of the tibia, and lastly those of the fibula.

FRACTURES OF BOTH BONES OF THE LEG may be produced either by direct violence, as by blows, kicks, or falls—the leg striking against resisting objects—or by indirect, as when a man falls from a height, alighting on his feet, or when the foot is caught, and the impetus of the body is exerted upon the upper part of the leg. It is not always easy to explain the mechanism of these injuries with exactness, although the general principles of their production can be readily understood. The whole limb constitutes a mechanical system; and if force be brought to bear upon it in such a way that the leverage is through the lower part, for example, of the leg, the foot being fixed, and especially if there be any twist impressed upon the bones at the same time, the bones will give way either where the stress is greatest, or at the weakest point of their structure.

Muscular action has in a very few instances been assigned as the cause of fractures in this region. Agnew[4] says: "A colored man was brought into the Pennsylvania Hospital with a fracture of the tibia and fibula, four inches above the ankle, which was caused by the violent muscular effort made to recover his equilibrium after slipping upon an orange-peel. He was thirty years of age, of an excellent constitution, and without any evidence whatever of pre-existing bone-disease. He had never before had a fracture." Gross mentions that "an instance of fracture of both bones of the leg by muscular action, in a man forty-two years old, has been recorded by Hevlhard d'Arcy." Hamilton says "Eight times I have found the bones broken by muscular action alone."

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[1] Gurlt, in his statistics, gives fractures of the malleoli separately; they numbered 32, and thus would be 11 per cent. of his 283 fractures of the leg. Middeldorpf gives 2, which would be about 3.5 per cent. of his 59 cases of fracture of the leg.

[2] See p. 21.

[3] Am. Med. Times, Jan. 5, 1861.

[4] Op. cit., vol. i. p. 981.

It does not often happen that both bones are fractured at the same level; very generally the fibula yields at a higher point than the tibia. Sometimes the fractures are very far apart, so as really to constitute separate lesions, as in two specimens mentioned by Stoker.[1] Here the tibia was broken low down, and the fibula high up, the obliquity of the two fractures being in converse directions. These cases, rare as they are, are not without analogues in the forearm. Occasionally the leg is broken in more than one place, when the violence is very great, as in some machinery accidents. Bransby Cooper[2] saw a case in which both bones of the left leg were fractured in three distinct places; the patient, a man aged forty-eight, had had his leg crushed over the side of a boat by the falling of a heavy weight; amputation was proposed, but he declined to submit to it, and although for a time his symptoms were very threatening, he ultimately did well, his convalescence being considered established by the eleventh week. In a specimen without history, in the Museum of the Pennsylvania Hospital,[3] "the shaft of the tibia presents three nearly equidistant, slightly oblique fractures, and several small fragments have been broken off from the bone. There are also three equidistant fractures of the shaft of the fibula, the upper two of which are oblique, the other transverse." A similar specimen is in the Pathological Cabinet of the New York Hospital.[4] The fibula is "broken near its upper end, while the tibia has been traversed by several very oblique fractures at and below its middle, separating the shaft into four fragments, all of which are firmly united by bone deposited between the opposed surfaces and in the cavities left by projecting angles."

Fractures of both bones of the leg at their upper part are always due to great direct violence, such as the passage of a wheel, the caving in of earth, entanglement in heavy machinery, etc. These fractures may or may not involve the knee-joint, and their exact mechanism is often difficult to determine. When the knee-joint is involved, it sometimes seems probable that the tibia first gave way across its long axis, and then that the lower or shaft portion was forced into the upper, bursting it into two or more fragments. The line of separation is seldom exactly transverse, but it is not often very oblique. Occasionally the fibula escapes; but this is a matter of small moment, not affecting the gravity of the injury, or influencing the symptoms.

In the Pathological Cabinet of the New York Hospital, there is a specimen[5] from a man, aged thirty-two, who had a compound fracture of the left tibia, caused by a blow from a heavy piece of iron. "Both tuberosities are separated from the shaft by a line of fracture running across the bone an inch or so below the joint, and a small portion of the internal tuberosity is still further separated by a fracture running from the first one up into the joint."

When both bones are broken in the upper thirds of their shafts, the fractures are as a rule oblique, and they are apt to be more nearly on a level with each other than when the injury is lower down. In the latter case, as before stated, the fibula is generally broken higher up than the tibia.

By far the largest number of cases, however, affect the bones of the leg either at or below the middle. I have said that the line of breakage is most generally oblique; yet it is not always so, and one or two specimens of almost exactly transverse fracture in this region have come under my observation. Tillaux says that one reason why the tibia is apt to break below the middle, is that it has there its least diameter; another, that it there assumes a cylindrical instead of a triangular form; and he mentions a third, "a peculiar arrangement of the bony tissue, pointed out by MM. Fayel and Duret; the cancellous structure of the tibia is, according to these authors, disposed in two independent systems of vertical columns; the one occupies the upper two-thirds, and the other the lower third, so that the minimum of resistance corresponds to the junction of the two systems."

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[1] British Med. Journal, Dec. 24, 1881.

[2] Guy's Hospital Reports, vol. i. 1836.

[3] Catalogue, p. 42; No. 1174.

[4] Catalogue, p. 122; No. 243.

[5] Catalogue, p. 116; No. 226.

In the middle, or indeed anywhere in the extent of the actual shaft of the bone, if force is applied to the tibia sufficient to break it, and especially if it be indirect, the fibula can scarcely escape: the exceptions being perhaps slight torsion, and such force as the kick of a horse, or any pressure brought suddenly to bear upon the tibia, for an instant only; in such cases the elasticity of the fibula may allow it to yield, and to spring back into shape. Sometimes, indeed, the slenderness of the fibula may exempt it from direct force which breaks the tibia. If the leg is strongly bent between the knee and the foot, both bones may give way at once, or the tibia may be first broken, and the fibula may yield secondarily from the stress put upon it when it is no longer supported by the larger bone.

Holmes[1] figures a specimen in the Museum of St. George's Hospital, showing "the lower epiphyses of the femur and tibia, and both epiphyses of the fibula, separated in the same injury; the shaft of the tibia is also fractured." He quotes also Prof. R. W. Smith's account of a case of separation of the lower epiphysis of the tibia, observed in a boy, aged sixteen, who recovered.

The *symptoms* of this injury are often very distinct. As a general rule, there is immediate loss of power, and the patient falls; but to this there have been noted numerous exceptions. Ormerod[2] mentions the case of a man aged thirty-two, admitted into St. Bartholomew's Hospital in 1843, who had sustained, by the kick of a horse, a transverse fracture of the right tibia a little below the middle, with fracture of the fibula in its lower third. He had walked to the hospital, consuming about four hours in so doing, with a crutch about the length of a walking stick; his leg was very crooked at the time of his admission. Bryant says, "I have seen more than one patient walk upon the fractured limb directly after the accident, and in one case a man went up a whole flight of stairs to his ward with but a slight limp. In another, under care in 1874, a woman with a fractured tibia and fibula went about for a week." A case is recorded[3] of a patient walking about for twelve days after sustaining a fracture of the leg.

Pain is very seldom absent, and may be very severe; there is always tenderness over the seat of injury, or if the limb is grasped above and below, and stress put upon the fractured portion.

The deformity is sometimes very slight, but may be extremely marked; its character depends chiefly upon the fracturing force. When this has been great, the limb may be wrenched entirely out of shape, bent, twisted, and perhaps shortened. But, as will be further detailed hereafter, in some very grave fractures there may be scarcely any change of form.

Preternatural mobility is another symptom which varies greatly in degree in different cases. Sometimes the lower part of the limb dangles in the loosest way, but sometimes the fragments are held together by interdigitations, so that there is very little movement between them.

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[1] Surgical Treatment of Children's Diseases, 1st ed. p. 259.

[2] Clinical Collections and Cases in Surgery, p. 50. London, 1846.

[3] Am. Journal of the Med. Sciences, Oct. 1845, from Recueil de Mém. de Méd., de Chir., et de Phar. Militaires.

Crepitus is rarely wanting, and is in general developed by the slightest handling of the injured limb.

Swelling occurs very rapidly, and may mask the other symptoms in a great degree. Ecchymosis also attends almost every case, by reason of the tearing of the periosteum; it often takes place only gradually, and increases for some days. I have repeatedly seen the discoloration of the skin outlast the period of consolidation of the bone. Along with the ecchymosis there is very apt to be a formation of bullæ or blebs, containing a more or less bloody serum; but these, if carefully let alone, will dry away without trouble. They are apt to be a source of great alarm to the patient and his friends, and to inexperienced practitioners.

Gross[1] says that a symptom which is seldom absent is "a spasmodic twitching of the limb, coming on soon after the accident, and frequently lasting for several days, or even weeks, much to the annoyance and distress of the patient." I have never had my attention called to this phenomenon unless other symptoms of disorder of the nervous system were also manifested.

The *course* of these fractures is subject to like variations. In some cases, after the first dressing, there is no pain, union takes place promptly, and the patient's only inconvenience is in the confinement necessarily imposed upon him. Sometimes, however, very grave symptoms manifest themselves. Mr. Green[2] reports a case of simple fracture of the leg followed by gangrene, for which amputation was performed, with a fatal result; the autopsy showed no wound of the vessels, which may, however, have been pressed upon by one of the fragments. The patient was a man aged forty-seven. Another case is reported by Trask.[3] Dupuytren[4] records six cases in which arteries were wounded by the fragments, the anterior tibial, the posterior tibial, and the peroneal being known to have thus suffered. Three times amputation was called for, and twice ligation of the femoral. Leigh[5] records the case of a man, aged forty-eight, who fell from a height, and fractured both bones just below the knee. On the twentieth day he was thought to have an abscess, which was punctured, but only blood escaped; two days afterward the wound was opened, and the anterior tibial artery was found torn across. The vessel was tied, but death occurred in a few hours. Borcheim[6] has published an account of a case of fracture of both bones, in which an aneurism of the posterior tibial artery was formed, and the femoral was tied at the apex of Scarpa's triangle; union was not interfered with. Edwards[7] has reported to the Pathological Society of London, the case of a woman, aged sixty-three, who was run over, sustaining a fracture of the right tibia at the junction of the middle and lower third. On the third day some bullæ appeared on the foot; on the fifth day the foot was cold; amputation was performed, but death ensued. "The anterior tibial vessels had been occluded by being nipped between the fragments; and a large blood-clot was found in the calf, pressing on the posterior tibial vessels." Stimson[8] says that Nepveu in a recent paper,[9] cites more than fifty cases of fracture involving injury to various vessels in the leg. Occasionally the nerves are likewise injured. Callender[10] records four cases of this kind, in which bullæ, causalgia, glazed skin, and the other phenomena recognized as due to nerve-lesions, were present.

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[1] Op. cit., vol. i. p. 991.

[2] St. Thomas's Hospital Reports, vol. i. 1836.

[3] Am. Journal of the Med. Sciences, Oct. 1850.

[4] Lesions of the Vascular System, etc.: Syd. Society's Translation.

[5] St. George's Hospital Reports, vol. iii. 1868.

[6] Medical Record, Dec. 30, 1882.

[7] Med. Times and Gazette, May 26, 1883.

[8] Treatise on Fractures, p. 568.

[9] Bulletins de la Soc. de Chirurgie, 1875.

[10] St. Bartholomew's Hospital Reports, 1870.

It must not be forgotten that fat-embolism, of which mention was made at some length in the early part of this article, is especially apt to ensue upon fractures of the leg, in which the conditions upon which that pathological process depends are more fully met than in fractures of any other part of the skeleton.

A peculiar form of fracture, affecting, almost if not quite exclusively, the lower part of the leg, was described with much accuracy by Gosselin,[1] nearly thirty years ago. Both bones are broken; but it is the lesion of the tibia which is important. This bone yields to a force of which torsion is a principal element, according to some observers the only one; but I think that there is ground for believing that there is first a flexion or cross-breaking strain. However this may be, the tibia sustains, first, a V-shaped fracture, the apex of the V presenting downward, and in some, if not in all the cases, on the antero-internal face of the bone, instead of along its crest. From this apex, or from a part of the V close to it, there runs downward a fissure, always in a spiral direction, to cross the ankle-joint, from behind forward, and then to run upward and join the main fracture at some other point. I think that the mode of production of this fissure will at once suggest itself in the lateral pressure of the apex of the V against the sides of the corresponding part of the lower fragment. This is the explanation admitted by Tillaux,[2] who has given a very clear and practical discussion of the whole subject. These fractures have been designated as V-shaped, wedge-shaped, spiroid, or helicoid; but none of these terms adequately describe them. The V-shaped portion is of importance only as, under torsion, causing the fissure; it does not act as a wedge; "spiroid" is at best a mongrel word, and neither it nor "helicoid" is suggestive of the very long and really but slightly curved line in which the bone splits. Tillaux thinks the phrase "oblique fracture of the leg" a good one, with the addition, if another epithet be required, of the word "helicoid." I venture to suggest that "Y-fractures of the tibia" would convey the idea of the essential features of the lesion.

Hulke[3] says that the fracture of the fibula, in these cases, always has more or less of the V-shape; and that this bone sometimes gives way at more than one point. Tillaux gives an instance in which it remained intact.

There are obvious reasons why fractures of the kind just described should be attended with danger of serious consequences. Besides the involvement of the ankle-joint, the damage done to the bone itself is extensive, and the medulla can scarcely escape bruising, hemorrhage into its substance, and interference with its nutrition. Hence, arthritis, osteo-myelitis, pyæmia, or septicæmia, may ensue, and cost the patient his life. Yet these risks are often successfully met, as in cases recorded by Gosselin. Two specimens are known to me, one in the Mütter Museum and the other in the Wistar and Horner Museum at the University of Pennsylvania, in which union has taken place in a very perfect manner, the line of the fractures, however, being clearly traceable.[4]

Fractures of the leg at its lower part have been sometimes said to be analogous to those at or just above the wrist; but it seems to me that this idea is apt to lead to error. Supra-malleolar fractures are in some small degree similar to those of both bones of the forearm close to the wrist; but even here the resemblance is but slight and superficial.

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[1] Gazette des Hôpitaux, 1855; Mém. de la Société de Chirurgie, tome v. 1855; and Bulletin de la Société de Chirurgie, tomes vi. et ix. See also Clinical Lectures on Surgery, translated by Stimson, pp. 90 *et seq.*

[2] Op. cit., p. 1149.

[3] Holmes's System of Surgery, vol. i. p. 1043.

[4] For further information in regard to these fractures, the reader is referred to the articles and works before quoted; also to an interesting paper on the subject, by Dr. R. M. Hodges, in the Boston Med. and Surg. Journal, Jan. 11, 1877.

The ankle-joint is a hinge, with no other motion except a very slight possible rotation of the foot in extreme extension. The astragalus is keyed or mortised between the malleoli, and if the foot is fixed, the leverage which may be exerted from above through the leg is very powerful. According to circumstances not easy to define, the stress may be brought to bear either upon both bones just above the ankle, or upon the inner malleolus and the lower part of the fibula. The outer malleolus sometimes suffers, as will be shown in speaking of fractures of the fibula alone.

Supra-malleolar fractures may be due to direct violence, or to a wrenching by outward or inward movement of the knee when the foot is fixed, or, as I believe, in some cases to extreme extension or flexion of the ankle, the foot being fixed. I have several times seen, in persons who had fallen from heights, alighting on the feet, fractures which seemed to be explicable in the latter way alone.

Fracture of the inner malleolus, with fracture of the fibula at some point generally about three inches above the ankle, is commonly known as Pott's fracture, having been first described with accuracy by the distinguished surgeon of that name. It had previously been regarded either as a sprain or as a dislocation.

Although, as I shall presently further show, this lesion varies greatly in different cases, there are certain features which always belong to it and distinctly characterize it. There are two ways in which it may be produced. When the foot is strongly everted, so that the sole looks outward, the internal lateral ligament is put upon the stretch, and a cross-breaking strain is brought to bear upon the inner malleolus, which gives way. As soon as this happens, the astragalus and calcaneum are forced up against the end of the fibula, which bends and breaks, generally at a point some three inches above. On the other hand, if the foot is strongly inverted, so that the sole looks inward, the inner malleolus may be, as it were, pushed off, while the outer malleolus is drawn inward, and the fibula gives way to stress tending to bend it outward.

In either case, the force is brought to bear across the columns of the cancellous tissue of the inner malleolus, while the point at which the fibula generally gives way is where it is slenderest and least able to resist.

By way of illustrating the differences presented by the lesions in these cases, I may simply quote the descriptions of three specimens in the Pathological Cabinet of the New York Hospital.[1] In one, taken from a man aged thirty, injured by the caving in of a bank of earth, "the fibula is seen to be fractured transversely two inches above the joint; the internal malleolus is torn off, and the posterior margin of the articular surface of the tibia is broken into three pieces."

In another, "the internal malleolus is broken off, and the fibula is fractured obliquely one inch above its lower end." No history of the case is given.

In the third, taken from a man aged fifty-three, who made a mis-step and fell upon the pavement, "there was a fracture of the fibula, commencing at the level of the ankle-joint, and running so obliquely upward and backward as to leave a fragment nearly three inches long connected with the astragalus. The internal malleolus was torn off, and the whole of the posterior third of the articulating surface of the tibia was comminuted and broken off by a fracture running upward and backward from within the joint, thus leaving several large fragments still attached to the astragalus below."

Occasionally the portion detached from the tibia is very small, consisting merely of the tip of the malleolus; and the lesion may then be properly ranked among "sprain-fractures."

The *symptoms* of the fractures now described are placed together here by way of contrast. Those of the "V-shaped fracture" are: projection, but not generally very marked, of the upper fragment; pain, utter loss of power, swelling, ecchymosis; mobility and crepitus only at the seat of the oblique fracture, the bone as a rule not being noticeably separated at the fissures. General tenderness always exists along the whole course of the fracture. Effusion occurs rapidly into the ankle-joint.

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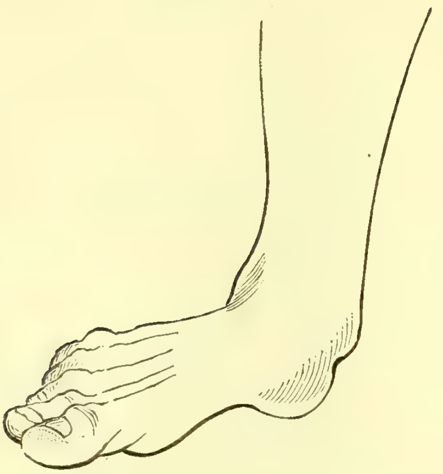
[1] Catalogue, p. 119; Nos. 233, 234, and 235.

Fig. 623.



Deformity in "Pott's fracture."

In "Pott's fracture" there is generally very marked deformity, the ankle being bent as in the cut (Fig. 623), and very movable until effusion has taken place in the joint. Ecchymosis occurs gradually.

Fractures of the lower portion of the leg, involving both bones, usually unite well, although some cases of non-union in this region are upon record, and sometimes consolidation takes place but slowly. In cases of Pott's fracture, unless the deformity is effectively remedied by treatment, the ankle remains permanently distorted, in a position similar to that of talipes valgus, and for a long time there is serious difficulty in walking. Sometimes, however, even when the bones have united in bad position, there is ultimately a much better result than might have been expected.

The *treatment* of fractures of the leg has long been recognized as a matter of great importance, and to describe all the contrivances for the purpose which have been brought forward would be a formidable task. I shall endeavor to give an idea of the principles to be carried out, and of the chief methods proposed for so doing, dwelling especially upon those which are of most practical value.

As in most other fractures, the main points are the correction of the deformity, the restoration of the normal shape of the part, and the maintenance of the limb in this condition until the fragments shall have become firmly united.

Sometimes the reduction is accomplished with ease, but sometimes it presents great difficulties. When the fragments are very loose, the distal portion of the limb dangling and very movable, the replacement is, as a rule, easier than when, though the displacement is less marked, the two portions of the tibia are interlocked. Very oblique fractures are sometimes attended with great overlapping, but this may be rectified without much trouble; its recurrence, however, can scarcely be obviated, except by well-adapted means, carefully applied.

Angular deformity is in general overcome by gentle manipulation, and ought not to be permanent under proper treatment. The rotation of the lower portion of the leg outward or inward must be carefully corrected, and in so doing the surgeon should make sure that both bones are placed in proper line; otherwise the tibia may be straight, but the fibula bent so as perhaps to give the patient a limp in his gait.

It will readily be seen that the reduction should be effected at the earliest possible moment, for two reasons: in the first place, because the swelling which soon ensues increases the difficulty of the procedure, and prevents the surgeon from judging how far he has succeeded in accomplishing his object; and secondly, because the resistance of the muscles is greater the longer the fragments have remained in their false position. Muscular action is not the sole cause, often not even the chief cause of the deformity, which is in general due to the fracturing force, or to the weight of the parts; but it very commonly is an obstacle to its correction. Hence this process is facilitated by relaxing the muscles, which is done by flexing the knee, and slightly extending the foot. Fractures which cannot be reduced at all with the knee straight will often yield promptly as soon as it is bent.

The test of the limb being in proper line is that the inner edge of the patella, the inner side of the ankle, and the inner side of the great toe, are in the same vertical plane. And the fingers passed along the tibia should detect no angular irregularity in its surface.

I have said that the main difficulties in reduction are due to interlocking of the fragments of the tibia, and to muscular contraction. Sometimes the condition of things is more complicated, and may be very obscure:—

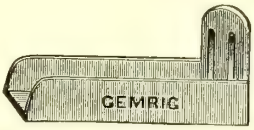
A woman, aged fifty, was brought into St. Joseph's Hospital, Philadelphia, having been run over by a wagon which had produced a severe compound fracture at the upper part of the right leg; reduction was impossible, although the most apparent obstacle was removed by cutting off the end of the upper tibial fragment, which protruded through the skin. Eight days afterward, amputation being performed through the knee-joint, it was found that the upper end of the lower fragment of the fibula was wedged in between the upper fragments of both bones, and that this had constituted the difficulty in replacement.

The reduction being effected, some surgeons are willing to trust for its maintenance to the pressure of a pillow, lapped around the limb and tied about with tapes or strips of bandage. Although this plan has been sanctioned by some high authorities,[1] I have never myself seen a case in which I should have felt justified in using it, except as a temporary resource.

Plaster bandages, the Bavarian splint, and other forms of solidifying dressing, have found many advocates within the last forty years, since the revival of this method by Larrey and Seutin. One objection holds against every form of it as a primary dressing for fractures of the leg, namely, that it prevents the constant inspection of the limb which can alone assure the surgeon that it is properly kept in shape. Skilfully applied, and carefully watched, I do not believe that the immovable apparatus is likely to do any harm by constricting the limb, although under other circumstances serious trouble has arisen in this way. At a later stage of the case, when the union between the fragments has become somewhat firm, a plaster or silicated bandage, or the Bavarian splint, may be employed to great advantage, enabling the patient to sit up, and to move about on crutches.

The "fracture-box" is an appliance which has long been used in the Pennsylvania Hospital, and which has some great merits. It consists of a board, having two sides attached by hinges, and a foot-piece. (Fig. 624.) The sides being let down, a pillow is laid in the box; the leg is carefully adjusted in the pillow, and the foot secured by a strip of wide bandage passed under the heel, its ends being then crossed over the instep and put through two slits in the foot-piece, to be tied at its outer side. Now the sides of the box are brought up, pressing the pillow against the leg so as to give it uniform and complete support. Of course, the size of the box must be adapted to that of the limb. If the fragments tend to form an angle forward, the heel can be raised; if backward, it can be lowered.

Fig. 624.



Fracture-box with movable sides.

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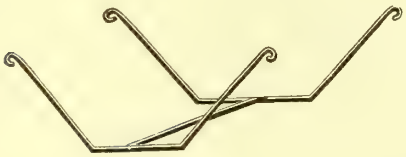
[1] Skey, Lancet, Jan. 9, 1864; Wicks, British Med. Journal, Nov. 25, 1882; Duke, ibid., Dec. 16, 1882. Sand-bags are generally added in order to promote the steadiness of the limb.

In England, the splint known as McIntyre's or Liston's has been very largely used, generally with a Stromeyer screw for the purpose of changing the angle of the knee when desired; and the ordinary double inclined plane has also been employed, not only by British surgeons, but on the continent of Europe and in this country. I think, however, that although there can be no question of the fact that good results have been obtained by such means, the want of more effective lateral pressure than is likely to be made by a mere bandage, and the uncertainty of posterior support through the muscles of the calf, make these forms of apparatus less available for general use than might be supposed from the reputation accorded them.

Lateral support, indeed, seems to me to be of prime importance in the treatment of the injuries in question; and my own practice is to employ it sedulously in every case. For this purpose I prefer moulded splints of binder's board, gutta-percha, or sole-leather, accurately adapted to the limb, properly lined or padded, and secured by careful bandaging, so as to control the leg and foot as perfectly as possible. Pressure upon the bony points, the head of the fibula, the malleoli, and the tarsal bones in very thin persons, must be guarded against by cutting out holes in the splints, and all the edges must be nicely bevelled. The side-splints should extend up along the side of the foot, so as to keep it steady and in line; but they should not reach so high as to interfere with the free flexion of the knee.

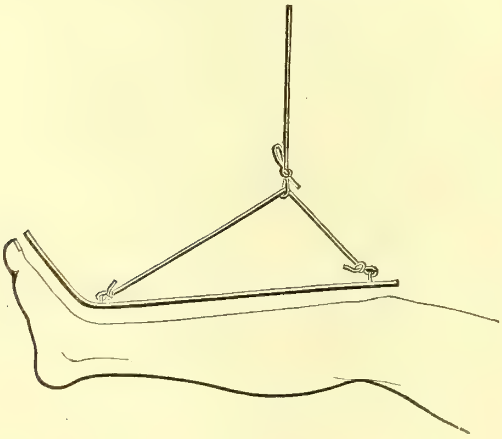
Patients with fractures of the leg are rendered far more comfortable by having the injured limb suspended, so that it can move freely without disturbing the fragments. By this arrangement they are enabled to sit up, and even to be out of bed, with perfect safety. When the fracture-box is used, it may be hung in a frame (Fig. 625) by means of cords attached to the ends of the arms; the frame should be made of iron bars stiff enough to sustain the weight without bending. When the lateral splints are employed, I prefer suspension by means of a

Fig. 625.



Frame for suspending fracture-box.

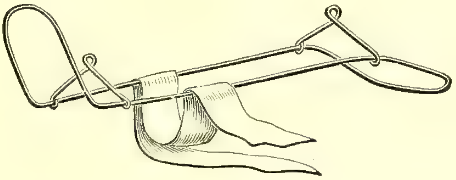
Fig. 626.



Wire frame for suspending leg.

wire frame like Smith's splint, using only the portion corresponding to the foot and leg. (Fig. 626.) In this frame the leg may be cradled by double strips of bandage, tied or pinned. (Fig. 627.) To attach the suspension apparatus, I use a support consisting of a wooden upright about six feet high, having at its top an arm at right angles, into the under surface of which is screwed a pulley; its lower end is set in a tripod, one long foot extending out parallel with the upper arm, and the other two at right angles to it. The long foot goes under the bed. A cord run through the pulley, with a tent-block, serves to attach the cords connected with the suspension-frame. From this description, I think the working of the whole apparatus may be readily understood. By having the gallows-frame unconnected with the bed, it may be moved to another part of the room, and the patient may be dressed and sit up, with his leg securely swung.

Fig. 627.



Mode of supporting leg with strips of bandage.

I may here mention that I have sometimes had occasion to move patients with fractures of the leg, and have found that they can bear the motion of a carriage or railroad train with perfect ease, by having the injured limb, properly splinted, laid on strips of rubber bandage nailed across a wooden frame supported on sides like those of a box.[1]

Other devices for suspension have been employed. Salter's swing is well known in England. The late Dr. Hodgen[2] published a description of a swinging fracture box, which was only open to the objection that, in order to let down the sides, the whole box had to be lowered and placed upon the bed. Dr. Nathan R. Smith's apparatus for fracture of the leg, consisting of a thigh piece, with a frame for the leg, and a foot-piece, is well known, and had a somewhat extensive popularity at one time. I do not think that it is largely used at present—perhaps, because it has been superseded by simpler and apparently more secure contrivances.

By some of the older surgeons it was advised that the limb should be laid on its outer side, secured by slips of wood bandaged so as to steady the bones, and with the muscles relaxed by bending the knee. Such a position would no doubt be comfortable, but it may be doubted whether the proper coaptation of the fragments would be effectively maintained. Yet it is spoken of with approval by Hulke,[3] as adapted to some cases in which "there is a tendency to displacement of the fragments when the leg is straightened." I cannot but think that suspension of the leg would answer the same purpose, with less risk of displacement.

Cases sometimes present themselves in which extension and counter-extension are required to counteract the tendency to shortening. Swinburne,[4] indeed, advocates the treatment of all fractures of the leg by this means alone, without splints or other means of lateral support; but I do not think that he has had many converts to this peculiar, and in my opinion dangerous, doctrine. Reference has been already made to the fact that Sands, St. John, and some others, have thought that a sufficient degree of extension was effected, even in fractures of the thigh, by firm lateral support and compression; this they would obtain by bandaging, with or without plaster of Paris, the limb being placed in such a posture as to relax the muscles. The experience of most surgeons, however, would lead them to seek more direct methods, in cases where shortening was seriously threatened; and a variety of appliances have been proposed and employed for the prevention of this evil, chiefly modifications of those already described in connection with the treatment of fractures of the thigh.

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[1] An arrangement of this kind is figured by Benjamin Bell (System of Surgery, Edinburgh, 1788. Plate lxxiii. Fig. 3), but with straps and buckles, and without any elastic support; it is described as an apparatus for compound fractures, to admit of the dressing of a wound without disturbing the limb.

[2] St. Louis Med. and Surg. Journal, March 10, 1871.

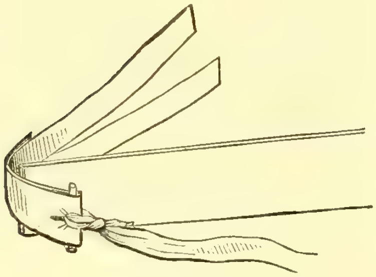
[3] Holmes's System of Surgery, 3d ed., vol. i. p. 1046.

[4] Op. cit., p. 25.

The method which I myself employ consists in the use of adhesive plaster, with the side-splints already spoken of.

Extension may be made by means of the side-splints, as follows: Four strips of adhesive plaster are cut lengthwise of the piece, and of length and breadth corresponding to the size of the limb—for an adult, about eighteen inches long by two inches wide. Each of them is then split up from one end for about half its length; the end which remains whole is next folded on itself, the adhesive surfaces in contact, and a small slip of wood is placed in the loop so made. A slit is now cut close to the bit of wood, through which a loop of bandage may be passed. The split ends being applied so as to embrace the ankle below and the upper part of the leg above, the strips are brought round the ends of the splints, and the corresponding pairs tied together on the outside of the latter. Extension is made by the two lower strips against counter-extension by the two upper, the force being increased or lessened by drawing the strips of bandage more or less tightly.

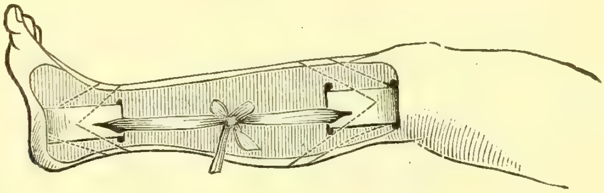
Fig. 628.



Side-splint for making extension in fractures of the leg.

This plan I have employed especially in cases of fracture near the ankle-joint, but I think that it will be found effectual whenever the bones are broken, at whatever point, so obliquely as to threaten overlapping and consequent shortening of the limb. It may be better understood by a reference to the cuts, Figs. 628, 629.

Fig 629.



Extension-splint adjusted.

A marked projection forward of the upper fragment of the tibia is sometimes observed, in cases especially where the fracture of this bone is very oblique. By elevating the heel, this prominence is, generally, almost if not altogether made to disappear; or perhaps it would be more correct to say that the lower fragment is thus caused to follow the upper, so that they are restored to their normal relation. Care must be taken not to overdo this, so as to produce an angle salient backward, which would give rise to most troublesome lameness. Ormerod[1] records two cases in which this anterior displacement was not manifested for some time after the receipt of the injury; under such circumstances it would seem attributable to defective treatment.

Section of the tendo Achillis, according to Malgaigne, was first proposed and employed as a remedy for this condition by Laugier. It would seem to have found more favor in England[2] than elsewhere; a case has very recently been reported by Bryant,[3] in which the operation was attended with success.

Malgaigne proposed, for the correction of this deformity, the use of a steel point on a screw stem, passed through the centre of a bow of metal, which could be fastened to the back splint by means of a strap and buckle; the bow being placed over the limb a little above the seat of fracture, the point was carried down through the skin, and screwed in so as to produce the requisite amount of pressure. An equally efficient and safer plan would be to substitute for the point a little plate carrying a pad. By slightly shifting the point of pressure from time to time, all risk of its injuring the skin could be readily avoided. I am not aware that Malgaigne's contrivance has ever been used, except in the very few instances mentioned in his work; and, indeed, nature does so much, in the way of rounding off projecting points of bone, that it would seem to me needless to interfere, unless the deformity were more marked than in any case that has ever come under my notice.

A curious consequence of fracture of the leg has been recorded by Terrier;[4] two months after the injury, a small cyst-like tumor showed itself on the inner surface of the limb near the fracture, and proved to contain free oil, effused from the broken bone; it was evacuated, and finally disappeared.

Pseudarthrosis is not uncommon after fracture of both bones of the leg. In Agnew's tables,[5] out of 685 cases, 100, or nearly 15 per cent., were in this region. In thirty-one of these the exact seat of fracture is not given; in one it is said to have been at the junction of the upper and middle thirds; in twenty-four at the middle; in six in the middle third; in nine at the junction of the middle and lower thirds; and in twenty-nine in the lower third. Hence it would appear that non-union is met with, in both bones, very nearly as often in the lower third of the leg as in the middle third; but the fact that in so large a proportion out of the whole number the exact seat of the lesion is not stated, prevents the drawing of absolutely positive inferences upon this point.

The treatment of this condition has been sufficiently discussed in a previous part of this article.

Union with deformity has been observed in a large number of cases of fracture of both bones of the leg, and is often productive of such total disability as to demand surgical interference. In not a few of these cases it has happened that the callus has yielded after the patients have begun to walk, and in almost all there has been a progressive increase of the bending of the limb. When the shafts of the bones are concerned, the angle is almost always salient anteriorly; I know of only a few exceptions to this rule, in which the bones projected backward. Toward the lower part of the leg, the deformity is, for the most part, like that of talipes valgus, the upper tibial fragment projecting inward, and the outer side of the foot being drawn up. In some recorded cases there has been atrophy of the bones also.

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[1] Op. cit., p. 54.

[2] See Med.-Chir. Transactions, vol. xxxiii. 1849, and Guy's Hospital Reports, 1855.

[3] Lancet, June 2, 1883.

[4] London Med. Record, Oct. 15, 1878, from Revue Mensuelle de Médecine et de Chirurgie, No. 7, 1878.

[5] Op. cit., vol. i. pp. 752 *et seq.*

The procedures resorted to for the relief of this condition have been of various degrees of severity. Norris[1] quotes Dupuytren[2] as authority for the use of combined pressure and extension, and cites a case thus treated with success by M. Desgranges, four months after the receipt of the injury.

Forcible refracture has been found effectual. Malgaigne cites cases from Bosch and Oesterlen, and one has been reported by Mussey.[3] In 1851, I witnessed the performance of an operation of this kind, by Dr. W. E. Horner, on a leg broken twelve weeks previously; the result was perfectly successful.

Brainard[4] made refracture easier by first drilling the bones at the abnormal angle; ten days afterward the callus yielded readily, and a good result was obtained. Hunt[5] resorted to similar means, and with ultimate success, although the patient's life was for a time in great danger.

Section of the callus was first performed, according to Malgaigne, by Oesterlen in 1815; afterwards by Dunn,[6] Portal,[7] Key,[8] Barton,[9] Mütter,[10] and Josse.[11] Norris mentions that he knew of similar operations by Warren, of Boston, and Stevens, of New York, and cites one by Rynd, of Dublin. I myself witnessed one such operation by the late Prof. Joseph Pancoast, and believe that he had others, never published.

The modern method of subcutaneous osteotomy, which seems admirably adapted to the treatment of deformed union in some situations, cannot be so readily employed in cases affecting the leg, for obvious reasons, unless the chisel is substituted for the saw. Dr. Fenger, of Chicago, has published[12] accounts of three cases in which he obtained success in this way. Another was reported,[13] and the patient, a man fifty-eight years old, shown to the Leeds and West Riding Medico-Chirurgical Society, by Mr. Jessop, of Leeds; the case was one of Pott's fracture, which had firmly united in such a position as to render the limb useless. A section was made through the fibula, 2½ inches above the ankle, and another through the base of the inner malleolus; and union was obtained so that the limb became straight and useful.

Compound fractures of the leg are always serious injuries, and are of very common occurrence in hospital practice. The damage to the soft parts may be due to the fracturing force, as in railway accidents; or it may be produced by efforts to walk on the part of the patient, by which the broken ends are thrust through the skin. Occasionally, the displacement being irreducible, the skin gives way over the projecting fragments, and a fracture at first simple becomes compound subsequently. Sometimes the fracture of one of the bones only is compound, that of the other being simple.

Often in these cases the question of amputation presents itself, and must be settled upon principles elsewhere laid down. If the attempt to save the limb be decided upon, I think it right to cleanse the parts thoroughly with carbolized water; reduction should then be accomplished, the wound closed, but with suitable provision for drainage,[14] and dressings applied. I prefer hot water, hot laudanum, or laudanum and lead-water. The fracture-box answers admirably in these cases, but my own practice is always to suspend it, not only because the patient is thus rendered more comfortable, but because the fragments are thus less likely to become displaced.

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[1] Contributions to Practical Surgery, p. 113.

[2] Injuries and Diseases of Bones, Syd. Soc.'s translation, pp. 63, 66, and 68.

[3] Am. Journal of the Med. Sciences, April, 1851.

[4] Chicago Med. Journal, Jan. 1859.

[5] Philadelphia Med. Times, Oct. 26, 1872, and Surgery in the Pennsylvania Hospital, p. 151.

[6] Med.-Chir. Transactions, vol. xii. p. 181.

[7] Am. Journal of the Med. Sciences, Oct. 1841, from an Italian Journal.

[8] Guy's Hospital Reports, 1839.

[9] Med. Examiner, Jan. 8, 1842.

[10] Am. Journal of the Med. Sciences, April, 1842.

[11] Quoted by Malgaigne.

[12] Medical News, April 15 and 22, 1882.

[13] British Med. Journal, April 14, 1883.

[14] See an excellent article by Markoe, on Through-drainage in Compound Fractures of the Leg, in the Am. Journal of the Med. Sciences, April, 1880; and a paper by Dr. E. Mason, with its discussion by the New York Surgical Society, in the Medical News, Jan. 7 and Jan. 14, 1882.

At a later stage, when, as very generally happens, suppuration ensues, and especially if the discharge be profuse, the bran-dressing devised by the late Dr. J. R. Barton is of great value. It is applied by means of a fracture-box, in which is placed a lining of muslin on which the bran is heaped, making a bed for the limb, which is then covered over with more bran, and the sides of the box brought up. It is not always necessary to secure the foot to the foot-piece, but it is better to do so if suspension is to be used. At this stage patients are apt to have become accustomed to confinement, and to have learned to lie perfectly still.

Bracketed splints of various forms, intended to control the limb while leaving the wound exposed for the purpose of changing the dressings, have been devised. Their value depends entirely upon the accuracy of their adaptation to the size and shape of the limb in each case; and it seems to me safer for most practitioners to rely upon simpler means.

As soon as the wound has healed, or the fragments have been so covered up by granulations as to be no longer exposed to the atmosphere, the lesion assumes the character of a simple fracture, and much of the danger is set aside. In the former case, the side splints, moulded to the limb, or the immovable apparatus, may be resorted to; but care should always be taken lest by undue or misplaced pressure the soft parts should be irritated, and fresh mischief ensue.

Various circumstances may arise in the course of cases of this kind requiring special interference. Extreme swelling and tension of the soft parts sometimes come on within a few hours of the injury, and may be greatly relieved by free incisions. Hemorrhage may occur to an extent that demands the use of prompt and thorough means for its control. At a later period, there may be burrowing of pus along the limb; and counter-openings, drainage, and properly applied pressure may be needed.

FRACTURES OF THE TIBIA alone are, according to some observers, much less frequent than those of the fibula alone; but the statements of others are decidedly at variance with this, as may be seen by a glance at the table quoted from Gurlt on a preceding page. The widest difference exists between the figures given by Malgaigne, 29 of the tibia to 108 of the fibula, and those of Blasius, 30 of the tibia to 15 of the fibula.

When the tibia is broken of itself, it is generally by direct violence, but sometimes by indirect. One instance has been recorded by Caspary,[1] in which it was thought that the bone had yielded to muscular contraction, in a strong healthy man of twenty-six; but as he had had a venereal sore six years previously, and had complained of rheumatic pains for some time before the occurrence of the accident, it seems probable that the texture of the bone may have undergone pathological change.

The fracture may be but slightly oblique; it is seldom as markedly so as when both bones give way. I have met with three recorded instances of incomplete fracture of the tibia. One, quoted by Malgaigne from Campaignac, was that of a girl, twelve years old, run over by a cabriolet; at her death the lesion just stated, with a curvature of the fibula, was ascertained by dissection. Gray[2] reported to the Boston Society for Medical Improvement the case of a boy of six, who "was standing on an iron rail fence, and in trying to jump down was caught by the heel and left hanging in that position;" the subsequent deformity, without crepitus, and the straightening of the limb by means of splints, seemed to warrant the diagnosis given, which, however, could not be absolutely verified, as the patient recovered. The third case was observed by Menzel,[1] of Trieste, in a man aged forty-eight, who was run over. There was some elastic mobility of the bone; the patient died of pyæmia, and "the left tibia was found partially fractured between the inferior and middle thirds; about seven-eighths of its substance was divided transversely; the remainder presented not even a trace of fissure."

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[1] Berl. klin. Wochenschrift, 28 Jan. 1867.

[2] Am. Journal of the Med. Sciences, Oct. 1853.

Sometimes, although the main line of fracture is nearly transverse, there are subordinate breakages, making a comminution of the bone. James[2] has recorded a case of longitudinal and transverse fracture of the tibia, with extensive extravasation of blood into the tissues of the leg.

Epiphyseal disjunctions have been observed in the tibia: Madame Lachapelle's case, in which the lower epiphysis of the femur and the upper of the tibia were detached in the delivery of a child, has been already mentioned, as has one of separation of the lower epiphysis of the tibia, quoted by Holmes from R. W. Smith. Stimson[3] has reported to the New York Surgical Society the case of a child, aged eighteen months, run over by a horse-car, in whom the upper epiphysis of the tibia was cleanly separated; the upper end of the shaft was denuded of periosteum, which was adherent to the epiphyseal fragment. A specimen of separation of the upper epiphysis of the tibia, from a crush of the leg which required amputation, is figured by Ashhurst.[4] The original is in the Museum of the Episcopal Hospital. Another case, in a boy of seventeen, has been placed on record by Quain;[5] the lower epiphysis was detached, the boy falling with his foot doubled under him. Martin[6] reports a case of compound separation of the lower epiphysis of the tibia, which may be mentioned here, although the fibula was also fractured about four inches above. The patient, a German boy, eleven years old, fell from about half the height of a telegraph pole. "The distal end of the shaft of the tibia had been separated from the epiphysis, and was protruding through the integuments. It had been thrust into the hard frozen earth, friction with which had stripped the periosteal covering of the bone from its entire external surface for the space of at least one and three-quarter inches. The peculiar stellate radiations of the extremity of the shaft where it joins the epiphysis were found to be perfect, when the dirt which had been packed into them had been removed." The boy recovered perfectly in two months.

Reference has already been made, in the early part of this article,[7] to "sprain fractures." Besides the instances there mentioned, a very instructive account is quoted by Hulke[8] from Dr. Hutton, with a representation of the specimen, of detachment of the spine and central portion of the head of the tibia, with part of its left articular surface, the fragment remaining adherent to the anterior crucial ligament. The injury was sustained in wrestling.

The *symptoms* of fracture of the tibia are not always very marked. Although the uninjured fibula is not strong enough to sustain the weight of the body, it is sufficiently so to prevent any great separation between the fragments of the tibia, and the deformity is hence limited. Some projection of the edge of one or the other fragment, generally the upper, can be felt on passing the fingers along the bone, and this is apt to be more marked, the nearer the fracture is to either end of the bone. Hays, however, has reported[1] a case of fracture of the internal malleolus, clearly defined, without any displacement. The pain is for the most part severe enough to forbid attempts at standing or walking. Crepitus may be felt, and decidedly, although the fragments may be but slightly movable upon one another. Swelling and ecchymosis are apt to ensue, just as in fractures of both bones; and even although the fibula is not broken, it may be bruised, so that this symptom will present itself on the outer side of the leg as well as in the neighborhood of the more serious injury.

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[1] London Med. Record, May 27, 1874; from Gazz. Med. Ital. Lomb., 28 Marzo.

[2] Australian Med. Journal, 1882; quoted in Index Medicus for May, 1883.

[3] Med. Record, July 15, 1882.

[4] Principles and Practice of Surgery, 3d ed. page 269, Figs. 132, 133. Philadelphia, 1882.

[5] British Med. Journal, Aug. 31, 1867; Holmes's System of Surgery, 3d ed., vol i. p. 1039.

[6] Boston Med. and Surg. Journal, Sept. 27, 1877.

[7] See page 19.

[8] Holmes's System of Surgery, 3d ed., vol. i. p. 1039; the original account is in the Dublin Hospital Gazette for 1846.

The *diagnosis* may be made out clearly enough as regards the fracture of the tibia, but it is by no means always easy to determine whether or not the fibula has also given way. On this point it will be better for the surgeon to restrain his curiosity; if mobility be not at once detected, it should not be vigorously or persistently sought for. In any case of doubt, the prudent course is to assume the probability of fracture.

When the tibia alone is broken, the *treatment* is essentially the same as that of fracture of both bones, and need not be again detailed. Non-union is very rare in these cases, by reason of the support, slight as it would seem to be, afforded by the unbroken fibula; yet Schüller has reported[2] an instance in which this condition was due to the interposition of the tibialis anticus tendon between the fragments; the patient, a healthy German woman, aged forty, had been run over by a wagon; subperiosteal resection was performed, and afterward the periosteum was sutured, with the result of obtaining complete bony union, with very little shortening, in four months. Sometimes consolidation takes place very rapidly. Schweich[3] relates the case of a peasant, aged forty, whose tibia was fractured transversely at about its middle, producing obvious displacement. A starched bandage was applied, and the reporter ceased his attendance on the sixth day. The patient walked in his room on the twelfth day, and returned to his work on the fourteenth. On the twenty-fifth he called on his surgeon, and exhibited a well-formed callus.

FRACTURE OF THE FIBULA alone may be produced by direct violence, at any point; when due to indirect force, it is generally seated within two or three inches of the external malleolus. In the former class of cases the mechanism is sufficiently obvious; in the latter it admits of some question, which is, however, not of serious importance. It may simply be said here, that it is probable that sometimes, as when the foot is brought very forcibly into abduction, so that the sole is turned outward, the tarsal bones are pushed against the malleolus so as to bend the fibula toward the tibia, and cause it to break at its weakest point. On the other hand, when the foot is violently adducted, so as to turn the sole inward, the stress upon the external lateral ligament may be such as to bow the fibula outward, and cause it to yield in the opposite direction, but at the same point—possibly a little lower down. Wagstaffe[4] has reported two cases in which, by a twisting movement, the lower end of the fibula was split longitudinally, and a fragment detached which became rotated and wedged against the tibia so firmly that its replacement was found impossible. In one, recovery took place, though walking was difficult; in the other, the patient dying in thirteen hours, the condition was verified by dissection.

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[1] Am. Journal of the Med. Sciences, Aug. 1837.

[2] Quoted in the London Med. Record, Dec. 15, 1878, from the Gaz. Hebdomadaire, 12 Juillet.

[3] Am. Journal of the Med. Sciences, Oct. 1848; from Caspar's Wochenschrift.

[4] St. Thomas's Hospital Reports, vol. vi.

When the fibula gives way by extreme abduction, there may be either a rupture of the internal lateral ligament, or a tearing off of the tip of the inner malleolus—sometimes of a larger portion. When the opposite condition obtains, the malleolus may be broken off by the forcible impact of the tarsal bones against it. But these cases have already been discussed under the head of Pott's fracture.[1]

The *symptoms* of fracture of the fibula are occasionally obscure. Sometimes the patient can walk, but there is always some pain, by reason of the fragments irritating the muscles, or by the slight strain brought to bear upon the broken part in the balancing motion of which walking so largely consists. Pain on pressure is always present, and swelling and ecchymosis are very apt to occur. Crepitus is generally very slight, on account of the small size of the bone, and there may be no perceptible deformity.

Keen[2] has pointed out, as a symptom of fracture in the lower third of this bone, a widening of the ankle, allowing of motion to a more than normal degree of the astragalus between the malleoli. This can be developed by grasping the leg above the ankle, at about the supposed seat of fracture, and then with the other hand taking hold of the astragalus itself. Malgaigne[3] speaks of the widening of the inter-malleolar space, but only very casually. Fractures of the fibula are sometimes attended with other serious symptoms, especially when the upper portion of the bone is involved. Duplay[4] has reported two such cases, in workmen caught in machinery bands and thrown against a wall. Among many other lesions, "there was found above the ordinary position of the head of the fibula a bony prominence, immovable, continuous with the tendon of the biceps. Below there was a manifest depression. . . . . A few days later, a paralysis of the extensors of the foot and of the peronei muscles was noted, due doubtless to lesion of the external popliteal nerve. . . . . In one case the diagnosis was verified *post mortem;* the other man left the hospital after several months, the paralysis remaining, as it still does." M. Perrin mentioned a similar case in a rider whose horse fell with him, and caught his right leg beneath him for a moment. There was "arrachement" of the head of the fibula, and very considerable diastasis of the knee-joint, with some effusion. Complete anæsthesia and paralysis of the anterior and outer part of the leg ensued. The ultimate result is not stated. Callender[5] mentions two cases of compound fracture of the head of the fibula, in both of which amputation became necessary on account of the injury inflicted on the peroneal nerve. Barwell[6] has recorded an instance in which fracture of the fibula was followed by the development of malignant disease. In the majority of cases, however, fractures of this bone unite favorably, and the functions of the limb are early and completely restored.

As to the *treatment* of fractures of the fibula, it may often be almost identical with that of other fractures of the bones of the leg. When there is no marked displacement, the limb may be simply kept at rest in a fracture-box, or done up with side splints, or with the Bavarian splint. If there is a strong tendency to either eversion or inversion of the foot, it may be corrected by placing a single long splint on the side toward which the foot is twisted, with a well-adjusted pad or long wedge-shaped compress to push the foot outward or inward as the case may be.

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[1] A very elaborate memoir on fractures of the fibula was published by Maisonneuve in the Archives Générales de Médecine, for 1840, and was republished in his Clinique Chirurgicale, tome i. Paris, 1863. The reader may consult it with advantage.

[2] Philadelphia Med. Times, Aug. 15, 1872.

[3] Traité des Fractures, etc., tome i. p. 813.

[4] Gaz. Méd. de Paris, 17 Avril, 1880.

[5] St. Bartholomew's Hospital Reports, 1870.

[6] British Med. Journal, Feb. 11, 1882.

FRACTURES OF THE BONES OF THE FOOT.

FRACTURES OF THE TARSAL BONES are not of very common occurrence. Those of the astragalus and calcaneum are the only ones which need be considered separately, although the other bones may be crushed, as in cases of railroad accident, or of other very great violence applied to the ankle—the fall of a heavy stone upon it, for instance. Such fractures are very apt to be compound, or to be attended with so much damage to the soft parts that amputation is inevitable.

FRACTURES OF THE ASTRAGALUS are very possibly more frequent than has been suspected, since they may easily escape recognition, and be regarded simply as severe sprains. Lonsdale[1] mentions a case in which the patient jumped from a height, alighting on his feet; there was no deformity, and the ankle was supposed to be badly sprained. Inflammation of the joint ensued, and the man died on the twelfth day, when, on dissection, the astragalus was found to be split in two or three directions. Here it seems to me that the violence was direct, although exerted through the medium of the os calcis. In a case recorded by Croly,[2] the fracture was due to the patient catching his foot in the stirrup as he fell from a horse; and here the force was probably indirect. Sheppard[3] observed, in the dissecting-room, four specimens of fracture affecting the outer projecting edge of the groove for the tendon of the flexor longus pollicis; in three the detached piece was connected by fibrous tissue with the rest of the bone, and in one osseous union had taken place. These specimens were without history; it would seem proper to place them in the category of "sprain-fractures." Neill[4] has recorded an instance in which the posterior extremity of the bone was broken off, and remained ununited.

Displacement of the broken portion sometimes takes place. Bryant says, "I have recently removed from the inner aspect of the ankle of a man the upper half of the astragalus, that had been fractured six months previously, and displaced so as to present its upper articular facet inward." This case had been previously supposed by the surgeon in attendance to be a fracture of the tibia and fibula. Vollmar[5] reports an instance of fracture of the head of the astragalus, in a stout countryman who fell from a height of eight or nine feet, and presented a bony prominence in the arch of the left foot. "In front of the articulating extremity of the tibia and fibula there lay, under the raised integuments, a bony swelling, separated by a deep depression from the outer malleolus." No hollow could be detected. Replacement was effected by extension, and in four weeks the patient was able to walk about.

MacCormac[6] has reported a fracture of the neck of the bone, the posterior portion only being dislocated, so that the trochlear surface was directed inward and slightly backward; the inner malleolus was also detached. He refers to a similar case seen by LeGros Clark. Other cases of fracture with dislocation have been recorded by Norris[7] and John Ashhurst, Jr.[8] Goyder[9] has reported a case of compound comminuted fracture of the astragalus, the malleoli being unbroken; recovery took place with a movable joint. In a case seen by Bryant,[1] a compound, complicated fracture of the head of the bone was produced by a fall from a height of some ten or twelve feet, the patient alighting on his feet. The head of the bone was removed, and the body of it restored to its normal position. Recovery ensued "with some use of the limb."

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[1] Op. cit., p. 531.

[2] British Med. Journal, March 18, 1882.

[3] Medical News, Aug. 5, 1882; from Lancet, July 1.

[4] Am. Journal of the Med. Sciences, July, 1849.

[5] Med. Times and Gazette, Jan. 27, 1855; from Zeitschrift für Chirurgie und Geburtsk., 1854.

[6] Trans. of Path. Society of London, vol. xxvi. 1875.

[7] Am. Journal of the Med. Sciences, August, 1837.

[8] Ibid., April, 1862.

[9] Med. Times and Gazette, Oct. 15, 1882.

The *symptoms* of fracture of the astragalus are only obscure when there has been great violence, and swelling occurs rapidly. If there is luxation of either portion, the deformity will call attention to it, when crepitus will probably be readily detected. When the bone retains its place, there will be tenderness on pressure across it, and crepitus may be perceptible. Walking, or standing on the injured foot, will be impossible. Swelling and ecchymosis will almost certainly come on; but a patient in my wards at the Episcopal Hospital, in 1882, presented neither of these symptoms, although the line of fracture could easily be felt, and crepitus was distinct.

The *treatment* in uncomplicated cases consists simply in keeping the foot at rest and preventing or allaying inflammation. When there is luxation, it may be a question whether the fragment should be removed or left to itself, if reduction is found to be impossible. In Norris's case one fragment was excised, and the other was allowed to remain; it became carious and loose, and was removed, but the adjoining bones also became carious, and at length amputation of the leg was performed, with a fatal result. In deciding the question of operation, the patient's age, habits, and constitution must be taken into account, the prospects of a young and sound person, who has never been debilitated by excesses or hardships, being much better than those of an old, or dissipated, or broken-down subject.

When the fracture is merely compound, the surgeon should be guided by general principles.

So great a probability of permanent stiffening of the ankle exists in all these cases, that a very guarded *prognosis* should be given.

FRACTURE OF THE OS CALCIS was formerly supposed to be always the result of muscular action; but it is now known to have occurred in a number of instances by crushing. I believe that the two causes are apt to be combined, the tension of the muscles of the calf acting strongly upon the posterior portion of the bone, and exerting a leverage which must aid in overcoming the resistance of its tissue to force applied from without. On examination of a vertical, antero-posterior section of a well-developed calcaneum, it will be seen that the arrangement of the cancellous structure is principally in radiating lines from the upper articular surfaces; and that although this is admirably adapted to meet the stress ordinarily sustained, it makes the bone, crushing being once begun, very liable to be rent apart.

The accident which has most frequently given rise to this injury is a fall from a height, the patient alighting on the heel. Lawrence[2] saw a case in which the patient had jumped from a stage-coach, and fractured the posterior part of the bone; the fragment was drawn upward by the muscles of the calf, but, upon pulling it into place, crepitus could be readily elicited. The case did well, although the patient halted somewhat in walking.

Costance[3] met with a case in which a woman, aged fifty, had her heel crushed under an overturned coach, and the fractured portion of the calcaneum was drawn up "as high as five inches." It could not be replaced, and the patient, after extensive inflammation and sloughing of the soft parts, recovered with the fragment firmly adherent in its false position, and its place filled by soft "cellular substance."

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[1] Lancet, June 2, 1883.

[2] Lancet, May 29, 1830.

[3] Am. Journal of the Med. Sciences, Nov. 1829; from Midland Med. and Surg. Reporter, May, 1829.

South[1] says that in the Museum of St. Bartholomew's Hospital there is a specimen of horizontal fracture of the tuberosity of the calcaneum, "extending to its hinder upper joint-surface, where it is continued upwards at nearly a right angle; the fractured piece does not appear to have been actually pulled out of place." He knew nothing of its history.

He relates a fatal case of compound fracture of this bone, under his own care, and quotes another seen by Lisfranc, in which union was first fibrous, and afterwards bony.[2]

Sometimes both calcanea are simultaneously broken. Of this Malgaigne says that he himself saw an instance, and that one was reported by Voillemier.[3] Fifield[4] records the case of a robust German, who fell about eighteen feet, alighting on his heels; in the right foot a compound comminuted fracture of the inner side of the calcaneum was at once detected, but in the left there was simply great swelling. About a month afterward, the swelling having subsided, a plaster bandage was applied, and in less than an hour the patient died from pulmonary embolism. The left os calcis was then found to be completely smashed.

Fractures of the os calcis by muscular action have been reported by Coote,[5] in a woman aged fifty-five, and by Anningson,[6] in a woman aged forty-two. Stimson[7] presented to the New York Surgical Society a specimen supposed to be of this character. The accident had occurred eight years previously, and the history of it was somewhat obscure. It appeared that the patient, a man then aged forty-five, had been knocked down by a passing wagon. "The fragment was the portion to which the tendo Achillis was attached, at least partially. It was more than an inch in length, and about three-fourths of an inch in breadth. On its outer side the periosteum was complete; on the inner side there was a growth of bone which presented the appearance of having been the result of reparative process. The fragment had united with the bone at its upper border, but was about half an inch anterior to its original position."

It seems to me that in some of these instances (the last mentioned, for example), the lesion might be properly ranked among "sprain-fractures."

Although it might seem very natural to expect that both the astragalus and the calcaneum would often suffer together, such is very rarely the case. I have, however, seen two specimens of this kind, one derived from a case of railroad injury, and the other said to have been caused by a fall on the heel. Of course in the crushes due to falls from great heights, to the passage of wheels, to entanglement in machinery, or to the fall of a heavy body upon the part, there can be no limit set to the damage likely to be done. In the Museum of the Pennsylvania Hospital[8] there is a specimen in which "the inner malleolus is broken off, and there is a transverse but fissured fracture of the fibula two inches above the malleolus. A small piece has been broken off from the postero-inferior part of the astragalus, and an irregular transverse fracture of the os calcis has occurred half an inch below its articulation with the astragalus." The patient had fallen from a second-story window; he refused amputation, and died of pyæmia, after erysipelas, sloughing, abscess, and secondary hemorrhage, for which the anterior tibial artery was tied.

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[1] Translation of Chelius's Surgery, vol. i. p. 640.

[2] See Archives Générales de Médecine, Janvier, 1828.

[3] Malgaigne gives no reference for this case, and I have not been able to find it.

[4] Medical News, Feb. 3, 1883.

[5] Lancet, April 28, 1866.

[6] British Med. Journal, Jan. 26, 1878. I find also in the Index Medicus for July, 1883, the following reference: Saussol, Un cas de fracture du calcaneum par arrachement; Gaz. Hebd. des Sciences Méd. de Montpellier.

[7] Annals of Anatomy and Surgery, July, 1883; also Medical News, Feb. 3, 1883.

[8] Catalogue, p. 45; No. 1189.

Fracture of the lesser process, or sustentaculum tali, has been studied and described by Abel.[1] It is said to be due to falls on the sole of the foot, or to forced inversion of the foot, so that the sole looks inward. The mechanism of such an injury is obvious.

The *symptoms* of fracture of the os calcis, as may appear from what has already been said, are not always such as to lead to its easy recognition. Of course there is pain, inability to bear weight on the heel, and tenderness on pressure, while sometimes the posterior fragment is drawn upward by the muscles of the calf acting through the tendo Achillis. But Malgaigne says that he mistook the lesion, in the first case seen by him, for fracture of the fibula, and that the same error was fallen into by Voillemier as well as by Bonnet; and it is very possible that surgeons of less experience have been deceived in like manner.

Abel says that when the sustentaculum tali is detached, any attempt to stand or walk everts the foot, giving the ankle the valgus position; crepitus and abnormal mobility, although present, may be masked by the swelling; but the astragalus and tibia are displaced somewhat backward, lessening the distance between the posterior border of the inner malleolus and the tendo Achillis.

The *course* of these cases can hardly be definitely laid down. Consolidation would appear to take place only very slowly, and it is apt to be a long time before the foot becomes useful again. I think that sometimes, in the cases of caries or necrosis of the os calcis, which are met with in children, there may have been in reality an unrecognized fracture, the nutrition of the bone being irretrievably damaged. The *prognosis* must always be doubtful.

As to the *treatment*, it must consist in obviating displacement as far as possible, by keeping the foot in a proper position, attention being at first paid, of course, to keeping down inflammatory action. The best dressing for these cases is a splint along the front of the leg, extending as far as the roots of the toes, and having an obtuse angle corresponding to the instep; it may be kept in place by an ordinary roller, and afterward by a plaster or silicate bandage. The old plan of putting a slipper on the foot, and attaching it by a band to a fillet around the lower part of the thigh, is open to the grave objection that the pressure of the heel of the slipper would itself tend to push the posterior fragment out of place.

FRACTURES OF THE OTHER TARSAL BONES can hardly occur except from crushing force, and present no features which need be dwelt upon. I have never seen such a case, except when the whole ankle was smashed, and when amputation was the only resource.

FRACTURES OF THE METATARSAL BONES result only from crushing, as by heavy weights falling upon the foot, and are nearly always compound. If amputation is not demanded, the only course open to the surgeon is to allay inflammation, and to keep the foot at rest until union shall have occurred. Any displacement of the fragments must be remedied as far as possible by careful manipulation; the result is apt to be favorable. Malgaigne says: "I recently had to treat a carter, who was thrown down under his vehicle, and had the three middle metatarsal bones broken by the wheel passing over them. The anterior fragments were very greatly depressed; there was a lacerated wound on the back of the foot, and the inflammation was most intense. It was therefore impossible to remedy the displacement, and, indeed, the saving of the foot could hardly be hoped for. The patient recovered, and could plant his foot very firmly on the ground, but the great projection of the upper fragments at the back of the foot obliged him to wear a peculiarly-shaped shoe." Hammond[1] reports a case of compound comminuted fracture of the right ankle as well as of the first and second metatarsal bones of the left foot, in which the patient made a good recovery without amputation. Boyd, however, has recorded[2] the case of a woman, aged fifty-nine, with fracture of the four outer metatarsal bones, followed by thrombosis of the femoral artery, pulmonary embolism, and death. Such cases are not very uncommon among the broken-down subjects of hospital treatment.

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[1] British Med. Journal, Nov. 9, 1878; from Arch. für klin. Chirurgie.

FRACTURES OF THE PHALANGES OF THE TOES are very rare, except from great direct violence. Yet I have several times seen them produced by accidents to persons bathing at the seashore, without serious injury to the soft parts, the pain, crepitation, and abnormal mobility placing the character of the lesion beyond doubt. In these cases the treatment is the same as for like injuries to the phalanges of the fingers, although the small size of the parts renders the aplication of splints at the same time more difficult and less needful. A little bit of pasteboard may be laid along the *back* of the toe, and bound on with a strip of adhesive plaster. I have never seen permanent lameness follow a hurt of this kind.

Compound fractures of the toes, as a rule, require amputation; but there is room for the exercise of judgment in deciding this question, as nature will sometimes do more in the way of repair than might at first be thought likely or even possible. The risk of tetanus from such injuries ought never to be wholly overlooked.

OTHER INJURIES OF BONES.

Besides fractures, the bones are liable to other forms of injury concerning which the surgeon should not be ignorant.

CONTUSIONS OF BONES are not very uncommon; and although the soft parts are also bruised, and the soreness in them masks that of the bone, yet there is often perceptible for a long time a deep-seated tenderness which gives evidence that the bone has suffered. Such injuries generally affect the superficial bones, and especially the tibia, which is very apt to be hurt in the rough sports of boyhood. As a rule nature repairs the damage inflicted in this way; but occasionally the results are more serious, and inflammation may ensue; the periosteum may swell, and necrosis of the underlying bony substance, or perhaps osteitis, may follow. In rare instances, and probably only where there is a constitutional vice, the nutrition of the entire bone becomes involved, and its inflammation or its death may take place. Or, if the disorder be more localized, an abscess may form in the cancellous substance, and give rise to very troublesome symptoms.

The *treatment* of contusions of bone consists in the enforcement of rest, and the use of hot-water dressings, and perhaps leeches; but it is seldom that the surgeon is called upon in such cases until the more serious secondary symptoms have declared themselves, the mode of managing which will be elsewhere detailed.

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[1] Trans. of the New Hampshire Medical Society, 1882, p. 105.

[2] Trans. of the Pathological Society of London, vol. xxxiii. 1882.

INCISED WOUNDS OF BONE sometimes occur. They are most frequent as the result of accidents in saw-mills, but are occasionally met with in carpenters or wood-cutters. I once saw an old man who had fallen with his knee on the upturned edge of a scythe, which had cut clean through the patella, and laid the joint open entirely across. Gross[1] mentions the case of a man, aged thirty-nine, who had had his olecranon severed by a cut with a butcher-knife; the joint was of course laid open, and there was free bleeding. Union took place with anchylosis. In 1876, I had in my ward in the Episcopal Hospital, a man aged twenty-five, who had had a very similar injury inflicted upon him with a "drawing-knife;" the closure of the wound was impossible, and I excised the entire joint, with a fairly good result, although the motion of the parts was very limited.

Of course injuries of this kind must always be compound, and their gravity will vary according to the seat and extent of the damage inflicted on the bone, as well as the degree to which the soft parts are involved. If a limb be cut entirely through, the question will necessarily arise whether union can take place or not. Some marvellous stories are told of cases in which severed fingers have been readjusted, and with perfect success;[2] but my own experiments in this way have uniformly failed.

The *treatment* must be adapted to the circumstances of each case. Sometimes it will consist simply in arresting hemorrhage, closing the wound, and putting the parts at entire rest by means of splints and bandages; just as in compound fractures. Sometimes amputation will be clearly indicated; and sometimes, as in my case above mentioned, excision may be the proper course.

PUNCTURED WOUNDS OF BONE have been met with, especially in Indian warfare. These have already been considered at sufficient length in the article on Bayonet and Arrow Wounds.[3]

I once myself, in making an autopsy, sustained a punctured wound of the second phalanx of the middle finger; the point of a scalpel penetrated the bone, and it was seven months before the wound healed, the bone itself remaining swollen and tender.

GUNSHOT WOUNDS OF BONE have already been fully discussed in the article on injuries of that class.[4]

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[1] Op cit., vol. i. p. 831.

[2] For one of the most extraordinary, in which the forearm is said to have been cut through all but a strip of skin, and to have healed again perfectly, see the quotation of General Hunter's case. (Med. and Surgical History of the War of the Rebellion. Part Second, Surgical Vol., p. 918, *note*.)

[3] See Vol. II. pp. 103 *et seq.*

[4] See Vol. II. pp. 123, 145 *et seq.*

DISEASES OF THE JOINTS.

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SYNOVITIS.

In order that the movements of joints may be both painless and innocuous, nature has clothed the ends of the bones which form them with cartilage, a substance singularly devoid of sensation, and very irresponsive to sources of irritation. Again, in order to bind those bones firmly together and to limit motion both in direction and amount, nature has employed a material which, on being tightened, does not cause pain nor respond to moderate tension by over-action and hyperæmia. Both cartilages and ligaments, being destined to withstand pressure and traction, support those forces with considerable indifference; they are both very inapt to take upon themselves primarily any inflammatory action, though such action may spread to them from neighboring parts. Hence, although in the dissecting or *post-mortem* room we occasionally find that the articular cartilages in a knee, shoulder, or other joint of a senile subject, are rough, velvety, villous, or even eroded, yet we find in such joints no other change, and inquiry, when it can be made, will show that during life no articular trouble was observed. Even such slight appearance of disease as this, does not occur by itself in the ligaments. Their structure seems incapable of independent morbid action, although it slowly takes part and shares in such as affects the common areolar tissue which binds together its fibres and permeates its meshes.

The other two constituents of joints—bone and synovial membrane—are very differently circumstanced. The former, although not particularly sensitive to slight causes of irritation, is by its very function of weight-bearer and lever, exposed to many kinds of traumatism; by its mode of growth, to many formative diseases; and by its constitution, perhaps by the function of its medulla, it is peculiarly susceptible to the influence of dyscrasiæ—to those of youth, of middle life, and of senility. The synovial membrane is one of the constituents of the body most prone to respond rapidly to slight irritants by intense reaction, and that reaction is usually strongly marked because its products, concentrated within a cavity, again affect the synovial tissue itself with painful and generally injurious tension.

Hence it happens that whatever the theories[1] concerning the origin of certain diseases in the cartilages or ligaments may be, we do not find, either in the wards or in the laboratory, that joint-diseases begin in the most insensitive and sluggish constituents of the articular mechanism.

The morbid appearances and the symptoms of an isolated chondritis or syndesmitis, supposing that such affections could exist, are unknown. The pathologist never sees, and the surgeon never has reason to suspect the existence of, such diseases.

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[1] The theories as to hip-disease commencing in the round ligament, and of arthritis deformans beginning in the cartilages, will be refuted hereafter.

It may then be taken as assured that the only maladies with which we have to do, arise either in the synovial membranes or in the bones of joints; some which, like the so-called loose bodies of joints, are results of disease rather than disease itself, originate sometimes in one structure, sometimes in another; while certain other maladies may perhaps begin simultaneously in both structures—involving rapidly the more passive parts—so that all after a short time go *pari passu* through the various phases of disease. Such conditions must stand over for future consideration, since they will be better understood when the phenomena of synovial and of osteal disease have been fully explained.

Synovitis may primarily be divided into acute, subacute, and chronic. Probably no diseases in the whole range of pathology arise from so many causes as acute and subacute synovitis; thus violence, wounds, over-fatigue, exposure to cold, rheumatism, gout, syphilis, and the absorption of morbid poisons, all give rise to synovial inflammation, and bestow qualifying names on the disease. Moreover, these causes impress upon the symptoms certain characters which the surgeon should clearly recognize. For instance, certain of them are causes which affect the whole system, and then we find that the disease attacks several joints, or is "multarticular."[1] The distinction must be borne in mind: "uniarticular," acute or subacute disease is local; "multarticular" maladies are constitutional.

The least complex forms of synovitis are those that follow some injury without open wound, but even in them certain distinctions are made.

SIMPLE SYNOVITIS.—*Simple synovitis* is also termed *sero-synovitis*, because the liquid in the joint, though excessive in amount, is not markedly changed in quality; it is a moderately clear, usually a rather thin synovia. But if the hurt have been more severe, and this applies especially to direct violence, as by falls or blows, this fluid is very likely to be mixed with and more or less deeply stained with blood; indeed, sometimes hemorrhage into the sac has been sufficient to cause the fluid to appear like unmixed blood, and so little is it diluted that in this *sanguinolent synovitis* the fibrin often coagulates out of the blood and floats in the cavity or falls upon its walls as shreddy flocculi. Again, in other cases, the cells cast off from the surface of the membrane—from the proliferating tissue[2]—and no doubt also a certain number of emigrated leucocytes, become sufficient in quantity to render a bloodless synovia opalescent, turbid, milky, even creamy; the fluid in the latter stage is indistinguishable from pus; but it is a surface-pus, rather resulting from perversion of an excessive secretion than from any inflammatory tissue-disintegration; thus, for instance, an ordinary leucorrhœa may become muco-purulent or frankly purulent, yet without any deeper suppuration, which, did it occur, would probably be called pelvic cellulitis or parametritis. Volkmann terms[3] this form of disease catarrhal; I have termed it *purulent* synovitis, in contra-distinction to *suppurative* synovitis—the much graver malady in which inflammatory pus is produced not merely on the surface, but in the substance of synovial and peri-synovial tissues, and even in the bones, by absolute disintegration of tissue. There is then a clear pathological and clinical distinction between this last disease and the other forms already mentioned. No doubt there may be in exceptional cases phases of transition, the inflammation at times tending to pass from a mere surface condition to a parenchymatous affection, and occasionally actually doing so, or, on the other hand, retrograding. But since the two forms of disease are in their natural history as in their gravity so different, it will be advisable to treat in the present portion of this article of *simple synovitis*, including the serous, sanguinolent, and purulent varieties, and of *dry synovitis*, leaving the *suppurative* form to a subsequent page.

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[1] Such diseases, although they may, after a certain time, implicate only one joint, always begin by attacking several others simultaneously, or in rapid succession.

[2] See, upon this point, Prof. Stricker's article in this Encyclopædia, Vol. I. pp. 26–30.

[3] Die Krankheiten der Bewegungsorgane. Pitha und Billroth, Handbuch der Chirurgie, Band ii. Abtheilung ii. S. 493.

Simple sero-synovitis usually follows some slight injury, such as a blow or a sprain, but a condition which locally is indistinguishable from this affection may follow simple over-fatigue, exposure to cold, or even some error in diet. The first pathological change is no doubt hyperæmia of the synovial membrane, and this is very rapidly followed by increased secretion into the cavity of the joint, or, if the hyperæmia be pretty considerable, by simple exudation rather than by exaggerated secretion. The fluid is in such cases thinner than normal synovia, and very soon, if not quite at first, becomes a little cloudy. This haziness may be so slight that it cannot be perceived by mere inspection of the fluid; but, if it be allowed to stand a few hours in a conical glass, a deeper deposit than normally occurs in human synovia will be observed. Examination of this deposit by a microscope of sufficient power, shows it to consist of endothelial cells that have been cast off from the synovial surface, and of leucocytes. Any considerable increase of these cells renders the fluid turbid, milky, or creamy, producing all the stages and phases between simple and purulent synovitis.

Sometimes the fluid, instead of being thinner, is thicker than normal, viscid, glairy, and somewhat sticky; such states of the secretion are most common when the attack is rapid and severe. This condition is undoubtedly produced by an exuberance of fibrin in the fluid, and this fibrin is very apt to coagulate (I had almost said crystallize out) into little floating glomeruli, which may be perfectly clear and apparently structureless, looking like drops of white of egg floating in water. But if the excess of synovia contain many cell-forms, these become inclosed or entangled in the gelatinous concreta, and they then appear hazy and white, like shreds of cotton-wool; or, again, if the disease be sanguinolent, the shreds are stained of a darker red than the surrounding liquid. These glomeruli are apt to fall upon and adhere to the articular parietes, cartilage or membrane, and there is great reason to believe, although I am not aware of any absolute proof of the fact, that their adhesion to a synovial surface produces at that spot a considerable amount of localized pain and tenderness. That they ever contract such organic adhesion as to become vascularized, and to aid in the formation of the hypertrophied fringes which will be described immediately, is doubtful.

In the mean time, and *pari passu* with the act of hypersecretion, the walls of the joint-cavity undergo certain changes. The capillaries immediately next to the surface are affected by those acts of dilatation and stasis which have already been described (Vol. I. p. 15 *et seq.*) as essential parts of the inflammatory process. The rapidity of cell-production on the surface increases; in some parts these proliferating bodies remain adherent; in others they fall away, leaving the basement membrane bare; while, at the same time, the parenchymatous constituents of the tissue increase, the whole, therefore, being thickened, and, in consequence of multiplication of its cell-elements, rendered slightly turbid. Thus, on looking at the surface of such a membrane, we see very plainly the blush of hyperæmia, yet not immediately on the surface, but through the slightly misty medium of a thickened basement and epithelium, which, by gentle touches of the finger, may be shifted a little from side to side over the vascular layer beneath. More especially, as from their structure might be expected, do the fringes, the parts most liberally covered with epithelial coating, increase in size and thickness; even the extra-vascular, secondary sacculi[1] enlarge and multiply, so that the villous surface is more thickly set and coarser.

A little later, a change takes place in the appearance of the cartilages. They lose their bluish translucency and become of a cloudy, milky-white hue. This has, by the more enthusiastic and less eclectic of Cohnheim's followers, been attributed entirely to the immigration of leucocytes. This is certainly an error; for, though it is true, as I have seen, that here and there, just below the surface, a body having all the appearance of an amœboid corpuscle may be found, yet a section of cartilage in this state shows clearly that the change is in the cartilage cells, which, first near the surface, and afterwards more deeply, are augmenting both in size and number, while here and there those narrow, compressed cells, which line the free edge of the section, are seen to have in part fallen away; in some spots to have become fuller and rounder.

By retrogression of these changes, the inflammation may now subside; the superabundant cells, no longer nourished by an extra blood supply, either fall off while still sound and normal, or shrivel and become detached, simply as epithelial scales, or, still more commonly, undergo fatty degeneration and float away or burst. In either way they increase for a time, or at least prolong, the turbidity of the fluid; and in any case they assist in adding to the mucin of the joint secretion;[2] soon, however, this regains its usual qualities, both of transparency and siziness. A very analogous fate befalls the cells contained in the lately inflamed tissue; they degenerate, liquefy, and disappear.

But if the disease continue, there become added to the local changes, which we will not now further follow, certain neuro-muscular phenomena, difficult to explain, but of deep importance in the natural history of all joint diseases. The exact period of their first advent is difficult to fix with absolute certainty, but they commence very early, as witness the difficulty and pain experienced by a patient with even slight inflammation of the knee when he attempts to straighten the joint, and a sense of dull aching, like an imperfect cramp, which is so frequently felt about the lower part of the biceps femoris. As the disease goes on, these phenomena become more marked, and in advanced phases of the malady play a very important part in its ultimate termination. The condition is at first merely an increase in the tonicity of those muscles which move the joint, and chiefly of the flexors. Hence a constant tendency of the limb to become during inflammation more and more bent.[3] Some writers suppose that both sets of muscles are contracted, and that the tendency towards flexion is due only to the preponderance of strength of the muscles which bend the limb. This is, however, not the fact, at all events in the earlier stages of a moderate inflammation. We may even question if, at that period, the extensors be not abnormally relaxed. Such a condition is generally very perceptible when the elbow is rather acutely inflamed: the biceps may be felt hard; its tendon rather tight; while the triceps is perfectly flaccid. But the most common instance is at the hip, where the tensor vaginæ femoris, with the sartorius and the flexors of that joint, may be seen as a ridge and felt as a tight cord, at the upper, outer aspect of the thigh, while abnornal flaccidity of the gluteus, causing flattening of the buttock and pendulousness of the fold of the nates, are among the most familiar signs of hip-joint disease. In ball-and-socket joints, both sets of capsular muscles, both inward and outward rotators, are thus contracted. This contraction is active, that is, is a shortening of the σαρϰος of the muscle, and is, I believe, closely connected with that sensibility to false positions or over-strain of joints which is called "muscular sense," and which always calls into play an instantaneous, often tremulous, muscular effort. This contraction is not to be confounded with "contracture," as, twenty years ago, I named that secondary effect of continuous muscular shortening which consists of gradual shrinking of the sarcolemma and other mere fibrous elements to the abridged dimensions of the active constituents of the muscle. Several results follow this over-tension of muscles, and among them two are for our present purpose important: namely, a constant tendency of the limb to become more and more flexed, even to an abnormal degree, and an amount of pressure on each other of the opposing spots of cartilage, greatly conducing to their inflammatory ulceration. But it must be especially remarked, that both sets of muscles, both flexors and extensors, undergo atrophy; the limb above the inflamed joint wastes rapidly up to a certain point; the flexors chiefly by fibrous, the extensors by fatty degeneration.

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[1] Rainey, Transactions of the Pathological Society of London, vol. ii. p. 110.

[2] Frerichs (Wagner, Handworterbuch der Physiologie) and I (Diseases of the Joints, 2d edition, p. 22; American edition, p. 15) have shown the mucin of synovia to be derived from the trituration of endothelial cells in an alkaloid fluid.

[3] A very few cases are on record of the contrary disposition, namely, towards extension.

At this point we may leave the anatomy of acute synovitis; that form of disease, be it simple or serous, sanguinolent or purulent, very seldom merges into suppurative synovitis, which, when it occurs, begins nearly always with an inflammation distinctly characteristic of suppuration, while a sanguinolent may become a serous, and that a purulent synovitis, the one merging into the other without any distinctive line of demarcation. Whenever suppuration of a joint follows what has appeared to be a less aggravated malady, the commencement has very generally been traumatic, the effused fluid strongly sanguinolent, the initial pain very severe, and pyrexia well marked.

Dry synovitis is a disease of very obscure etiology; it rarely attacks any joint other than the knee, is not unfrequently traumatic, and is most often observed in persons of a rheumatic constitution, though it is not to be taken as a mere rheumatic inflammation. Volkmann terms it croupous, and it certainly coincides with an absence of fluid contents or of marked swelling, and with the presence of a hard, leathery condition which can hardly be otherwise produced than by the coagulation of fibrin in and about the synovial membrane. We have seen that the persistence of pain in a limited spot of a joint which has suffered from an ordinary but severe synovitis is, in all probability, due to the presence of a coagulum, which, having formed in the fluid, has become deposited on the synovial surface; and the very severe suffering of dry synovitis appears to be due to a coating of the whole inner surface by a firm tough lining of fibrin, which glues together all the synovial folds, recesses, and fringes; nor does such deposition confine itself to the interior of the joint, but invades also the periarticular tissues; nay even the tendinous sheaths, fibrous or cellular, are likewise involved, so that the tendons become adherent for a considerable distance. A case of dry synovitis of the wrist-joint, which I unfortunately only saw rather late in the disease, was strongly characterized by firm tendinous adhesions a considerable distance up the arm and down to the phalanges. Generally this disease ends, even after long suffering, in resolution, occasionally with rapid absorption of the fibrin, so that but little stiffness may remain; but more often considerable stiffness, both intra-articular and extra-articular, results. Occasionally the disease ends—indeed it has considerable tendency to end—in true anchylosis of such rapid production that it takes even watchful surgeons by surprise. The extremely rapid production of true anchylosis is very remarkable; it can only occur in one of two ways, either the cartilages and their bony substratum must disappear, or they must coalesce and become ossified; such rapid dissolution of cartilage without suppuration is most unusual, while the fusion together of two cartilages is hardly recognized as a pathological process. Yet I have known a joint to become completely ossified in three weeks (22 days) after the first attack of the disease.

Another termination of dry synovitis, fortunately not a common one, is that after a fresh access of pain, probably a rigor, and a certain change in the character and type of fever, very acute suppuration will set in. The suppuration is very widespread, and appears to involve all the newly deposited fibrin; hence, according to the distance from the joint at which that deposit has occurred, the suppuration will involve periarticular and adjacent tissues, tendinous sheaths, and inter-muscular spaces. The character of the inflammation is severe, and quickly involves the vessels, thrombosis and blood poisoning following very rapidly.

SYMPTOMS OF SIMPLE SYNOVITIS.—It has been stated that synovitis of the serous, sero-sanguinolent, or purulent variety, may be produced by very various causes, and that certain differences in the symptoms depend upon the particular cause concerned. These differences, much more easily pointed out at the bedside than described in writing, consist in modifications in the proportional intensity of different symptoms; sometimes in additions or omissions from the general array of phenomena. The simplest picture of an ordinary synovitis may be drawn from that form of the disease which follows some injury, of a character not too severe. But before going on to the description of these various types, it will be well to lay especial stress upon the inferences to be drawn from the uniarticular or multarticular form of the malady.

It certainly may happen that by some fall or accident more than one joint may be injured; there may be multiple contusions or sprains just as there are multiple fractures; such an occurrence, however, could be easily verified, and the plain fact would lead to a ready conclusion. But when without a traumatism of this complicated description, a patient develops synovitis in several of his joints, we may come to the conclusion, or at least strongly suspect, that some constitutional condition has produced or originated the disease. The contrary does not hold good to quite the same extent, and especially cannot be assumed in chronic disease. Even when the case before us is acute or subacute, and at the time uniarticular, we must make sure of our ground; for, as we shall see hereafter, certain forms of malady begin with slight and transient, though very painful, manifestations in many joints, and end with more severe disease of one.

The four cardinal symptoms of inflammation, redness, heat, pain, and swelling, are all present in synovitis; but *redness* is in simple cases imperceptible, simply because the inflammation, though present in the deep parts, does not affect the cutaneous surface of the joint. *Heat* is, except in trivial cases, always present, though often to so slight a degree that this cannot be verified by the hand. Severe simple synovitis may cause a difference of 1.5° F., or as in one of my cases, 2.4° F., between the affected and unaffected sides.[1] If synovitis produce a greater rise of temperature, a suspicion should be aroused either that it is suppurative, or that it depends on some constitutional cause, such as rheumatism, gout, etc.

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[1] I have not found thermometers for taking surface temperature trustworthy, the elasticity of the glass permitting a slight pressure to cause a considerable rise of the mercury, while the contrivances to prevent such an effect appear to reduce the sensitiveness of the instrument. My method is to apply the ordinary clinical thermometer for several minutes under a thick layer of wadding.

The *pain* of a sero-synovitis is not, as a rule, severe, while the limb is at rest, and especially after it has been motionless for some time. In other words, movement causes pain, which slowly subsides during quietude. The pain consists in a duller or sharper aching, according to the amount of tension, and at the same time in a sense of distension, fulness, or bursting; throbbing is very rare, its presence, or at least its prominence, marking a condition other than that of simple synovitis. Many persons, especially those of irritable or sensitive idiosyncrasy, complain of an uneasy aching, a dull sort of cramp about the flexor muscles or tendons. This is most commonly remarked while the patient is in bed, and while the limb is unsupported. But besides the general joint-pain above described, there is in every larger articulation a special place which is more painful and more tender than any other part. These painful spots will be referred to in connection with the peculiarities of tumefaction of each joint.

The *swelling* of simple synovitis, since infiltration of tissue is an intrinsic part of the process of inflammation, must occupy some space outside of the synovial membrane; but this external swelling is quite trivial in amount, and in the presence of much larger and greater tumefaction, is hardly or not at all perceptible. The enlargement on which the mind of the surgeon is fixed is that which is due to hypersecretion of fluid within the synovial sac, whereby it is filled out or distended to abnormal size.

The swelling therefore is fluctuating to the touch, and, according to the amount of effused fluid, more or less tense. If the joint be superficial, as the elbow, knee, or wrist, the fluctuation is, like the tumefaction, very easily detected; whereas if it be deeply seated, as for example the hip, both symptoms are obscure, and only to be recognized when the amount of fluid is very considerable. Certain very important points in semeiology arise from this distension of the deep parts of the limb. It is to be noted that every joint is crossed by certain ligaments and tendons, which leave between them parts where the synovial membrane is less covered. Most of these structures make, beneath the skin, prominences, which may be seen or felt, and which help to give what an artist would call "character" to the part; if they were eliminated the joint would look (again in artist language) "dumb" or "lifeless." Now this is precisely what takes place in slight synovitis: the distended sac, bulging out between the ligaments and tendons, obliterates their prominences, and the joint looks evenly rounded—dumpling-like, or dumb. But if the effusion become greater in quantity, a further effect follows: the interspaces between the ligaments and tendons protrude further than those structures, that which normally was a hollow becomes now a prominence, and *vice versa*. Hence a peculiarity of shape for each inflamed articulation, according to the position and form of the bands by which it is crossed.

We will take together the form of swelling and the special seat of pain for each important joint.

Shoulder.—The shoulder looks fuller and broader than that of the other side,[1] and the groove which separates this part from the chest is, especially at the upper end, very inconspicuous. These changes may best be seen by looking down upon the shoulders, the patient either kneeling or sitting on a low chair. In persons not too obese, there is at the back of the shoulder a shallow depression just below the acromion; this becomes filled up in synovitis. In severe cases the apex of the axilla is blunted, and to its outer side tumefaction may be made out. The especial seat of tenderness and pain is in front, just below the acromion.

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[1] The natural differences between the right and the left arm must be kept in mind.

Elbow.—The elbow is a joint of complicated construction. The points at which the swelling of acute synovitis makes its appearance, are chiefly at the back. Thus the depression which lies on each side of the triceps tendon, and one which marks the place where the radius joins the humerus, become first obliterated and afterwards form rounded prominences; the line of the triceps tendon becomes a broad depression. Especially characteristic is the soft fluid swelling at the junction of the radius and humerus. A wave of fluctuation may be easily made to run from any one to any other of the above-named places. It is at the interval between the radius and the humerus that pain is chiefly felt.

Wrist.—At the wrist also, the swelling is chiefly manifested behind, namely on each side of the extensor tendons of the fingers, and between those of the thumb. This tumefaction gives to the lower part of the arm, behind, a bracelet-like enlargement very easily distinguishable from dropsy of the tendinous sheaths, for (1), its long axis is transverse to that of the limb; (2), it does not encroach on the carpus and metacarpus; and (3), it is neither fusiform nor bifurcated towards its lower end.

Hip.—The hip is rarely affected with pure, simple synovitis, which, when it does occur, is either traumatic or the result of over-exertion. The swelling in such cases hardly makes any appearance on the surface, but the condition is chiefly manifested by certain abnormal positions of the limb, which produce an appearance of either abnormal lengthening or shortening.[1] When distension of the synovial membrane is sufficient to cause perceptible swelling, it is found behind the great trochanter and in the lower part of the groin, that is to say, at a place below the middle of the line separating the thigh from the abdomen. If the patient be thin, fluctuation from one to the other of these spots may be detected. Another place where tumefaction can be felt, is in the angle between the thigh and the perineum, a little behind the tendon of the adductor longus muscle. This disease gives rise to a good deal of pain, which runs down the thigh and is often referred to the knee. Two adjacent bursæ may, when inflamed, produce symptoms which on inadequate examination simulate hip-disease. One of these lies beneath the tendon of the ilio-psoas, and upon the head and neck of the femur, as low as the lesser trochanter; it frequently communicates with the synovial membrane of the hip-joint. When it is a separate sac, and becomes inflamed, it gives rise to a considerable swelling in the lower groin, while the post-trochanteric fossa is unaltered. Flexion of the thigh on the abdomen is painless, while extension, especially when combined with inward rotation, is intolerable. The other bursa, a very large one, is placed under the gluteus maximus; when distended, this bursa produces a broad, rounded swelling, which occupies more than the parts behind the great trochanter; indeed, the soft parts directly over that bone are increased in mass, so as more effectually to conceal it.

Knee.—The knee, being both large and superficial, is more often affected with the various forms of synovitis than any other joint of the body, and the disease is owing to these two peculiarities very easily detected. Normally, the tendon of the rectus, the patella, and its ligament, form along the middle of the joint, in front, a varied and undulating projection, on each side of which are depressions. When the synovial sac becomes filled, these latter are obliterated. When very tense, they become prominent, so that what in health are projecting parts, are transformed by a severe acute synovitis into hollows. Moreover, the accumulated fluid presses the patella a little way forwards, away from the femoral condyles, so that when the surgeon presses it sharply back, it knocks against the deeper bone very decidedly, and at the same time the swellings at the side become still more prominent, by displacement of a wave of fluid from the front; fluctuation is thus absolutely visible. Also, when any considerable amount of hypersecretion is in the joint, it protrudes into the popliteal space, which thus becomes shallow or even obliterated. An inflammation of the bursa patellæ causes a semi-globular or conical prominence in front of and concealing that bone. It can hardly be mistaken for swelling of the joint itself, and another bursa, situated under the ligamentum patellæ (occasionally communicating with the knee), produces very localized pain, and a swelling which resembles enlargement of the tubercle of the tibia.

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[1] These postures will be fully explained when I come to speak of hip-disease.

The special seat of pain, in the case of this joint, is a spot in front of the inner condyle, a little inside the edge of the patella.

Ankle.—The ankle-joint is not unfrequently the seat of acute synovitis, but rarely of a severe character; the disease either becomes chronic, or quickly disappears. The swelling is chiefly in front of the malleoli, more especially in front of the outer malleolus. A less degree of enlargement is observed behind, but the extensor tendons are pushed a little forward, so that the whole tumefaction stretches from behind one ankle bone around the limb to the back of the other. This characteristic serves to distinguish the affection from the effusion into tendinous sheaths, which so frequently follows sprains or exposure to cold. In synovitis, the swelling runs like an anklet around the limb; in the tendinous affection, it runs lengthwise on the leg, and encroaches somewhat on the instep.

The *constitutional symptoms* of simple synovitis are very slight. If the attack be traumatic, and be accompanied by bruising, or if the pain be very severe, some slight pyrexia is usually present, but it generally subsides rapidly. Continuance of pyrexia indicates that the disease is assuming a more or less purulent character, but even then the thermometer is very little over 100° F. A higher temperature, 101.5° to 102.5° F., marks a more severe condition; it may be suppurative synovitis, or perhaps rheumatism. The former is rarely grafted upon the simple form of the disease, and is preceded, as a very general rule, by more severe pain, and more especially by rigors.

SYMPTOMS OF DRY SYNOVITIS.—The symptom of dry synovitis, which, by its prominence, masks all others, is pain. This disease rarely attacks any other joint than the knee, and, although it is not at all like the joint inflammation of acute rheumatism, it has very marked preference for persons of a rheumatic constitution. The commencement is gradual, the patient suffering from only the ordinary, not very severe pain of an ordinary synovitis; the fluctuating swelling, already described, is however but slightly marked. After a few days this pain, instead of decreasing, becomes more severe; probably a sleepless night of considerable suffering is the first intimation of some more violent attack. Probably the surgeon, having been told of this pain, will expect to find a greatly swollen joint with signs of impending suppuration, and will be somewhat surprised to see but very little enlargement, no redness, and no appearance of increased fluid in the synovial sac. Even the appearance of swelling which he observes, is not as great as it looks, as may be verified on measurement, but in this form of disease, wasting of the muscles above, is extremely rapid—more so than in the serous variety—and this causes the joint to look larger than it really is. The form of the swelling is very different from that which has been described above; it is not so round, with protuberances between ligaments and tendons, but has a peculiar, angular, or square look. To palpation, it is not soft and fluctuating, but hard, elastic, and leathery. If the finger be passed down the limb from the healthy to the inflamed parts, it perceives, on reaching the latter, a distinct, rounded edge to the tumefied joint. The skin very soon becomes rather tightly drawn, and then often assumes a browner shade than the part above and below; that is, the parts immediately over the joint are a little browner in dark, and a little yellower in blond individuals.

In severe cases palpation must be very gently employed, as it generally produces severe pain; although I have seen two cases in which pressure by the whole hand was painless, though by the finger-tip it was unbearable. But the pain which the patient complains of is not mere tenderness—it appears agonizing; and although it is described as constant, there must be intervals, since he generally gets some sound sleep, perhaps two or three times in the twenty-four hours. Even those who insist that the pain is constant, nevertheless speak of paroxysms of greater severity; but—and this a very marked peculiarity—in spite of the severity and duration of pain, the health suffers but little.

The *constitutional symptoms of dry synovitis*, although more marked than those of the simple disease, are by no means commensurate with the amount of pain; indeed, it is chiefly upon the contrast between the intense pain which the patient complains of, and the comparatively low temperature, the absence of rigors, and the almost clean condition of the tongue, that the surgeon will rely for his diagnosis; or, at least, it will probably be this disparity that will first lead him to believe that the joint is not suppurating. Very generally, too, the appetite remains good, so that in the intervals of ease, or of comparative ease, food is taken with relish. As the small amount of pyrexia would indicate, there is no excessive thirst; although the pain is described as incessant, yet, as already remarked, but few cases of continuous pain really occur; nearly all patients obtain, during the twenty-four hours, some quiet sleep, even without the aid of opiates.

The skin is generally dry, but occasionally profuse perspirations of acid odor occur; and in some cases these are nightly, and very excessive. The urine is high colored, but not particularly scanty; it frequently, on cooling, becomes covered by an iridescent film. The most usual deposit is deeply stained lithate of ammonium; pure uric sediment is rare. If, after this disease has lasted some days or weeks—and its duration in this form is very uncertain—the thermometer rise suddenly to over 102° Fahr., more especially if such elevation have been preceded by a sharp rigor, the probability is that the type of the disease is changing, and that the suppurative form is about to appear. This change, although in my own experience very unusual, certainly does occasionally take place.

TREATMENT OF ACUTE SIMPLE SYNOVITIS.—Since, as we have seen, the constitutional symptoms of simple acute synovitis are very slight, so it is evident that but little general treatment is required. Three points should always be considered: the state of the bowels, the condition of the urine, and the amount of pain. With regard to the first of these, I would recommend that, unless the action of the bowels has been during the previous few days quite free, an aperient, or in some cases a purge, should be administered. The choice between these two somewhat different remedies should be based on the following considerations: aperients only should be given if the patient be moderately spare, if he have not a full abdomen, and if the affected joint be of the upper extremity. But if the patient be rather stout, and have a full, large abdomen, it may be wiser to give the stronger remedy; and if a joint of the lower limb be involved, and especially if the individual be in the habit of taking much exercise, a purgative should be employed, since he must certainly be debarred from his usual active habits, and very likely must be confined altogether to a bed or couch. The choice of particular drugs, whether cholagogues, hydragogues, or mere alvine purges, must depend on the state of the tongue, the color of the conjunctivæ, and other principles of general medicine.

Many patients, suffering even a mild inflammatory attack, one which barely raises the temperature, show at once some constitutional response to the disease by a rather scant and high-colored urine, which, in some persons, deposits uric acid. In such cases it is well to give some diuretic, probably—indeed certainly if there be uric acid deposit—combined with an alkali, nitrate and carbonate of potassium, with nitrous ether, or an effervescent draught containing citrate of potassium and ammonium; while, if the uric acid deposit be pretty copious, a little wine of colchicum may, for two or three days, judiciously be added.

It is rare that the pain of sero-synovitis is sufficiently severe to need opiates. Traumatic cases may, however, require these remedies for the first night or two. The most reliable indication for such medication is the amount of pain, which is not merely to be regarded as a passing and temporary infliction. Pain produced by inflammation is, I am sure, a direct irritant, and a cause of its persistency. Opium or morphia, by the mouth or subcutaneously, are the most reliable remedies; but smaller doses may be rendered sufficient by combination with atropia, or with bromide of potassium; or, again, if the fever be pretty well marked and the skin dry, with a small quantity of tartarized antimony. Chloral as a remedy for pain is unreliable, or even useless. Another drug should be mentioned. I have rarely had occasion to use it, but when it has been called for I have found it valuable, especially when the fever has run high. I refer to aconite, which in these cases is most useful; its mode of administration and its action will be more fully discussed when the treatment of dry synovitis is under consideration.

The *local treatment* of acute or subacute synovial inflammation,[1] consists, in great part, in rest. This word does not merely mean that the patient is to abstain from active exercise and keep the limb motionless; indeed, such voluntary abstention from, such guarding against, movement, is often the very reverse of physiological, producing, if not quite at first, yet after a certain interval very considerable, and frequently painful, muscular effort. To keep a limb really at rest, it is necessary to secure it in some stiff support, which shall prevent movement independently of, and in spite of, muscular action. But before doing this, it is necessary to consider the position of the part. If the surgeon be called in while the disease is still quite recent, he will find the joint in no forced position, and, in all probability, easily movable without any marked pain. But if called in later, and more especially if the synovitis have come on rapidly with unusual severity, he may find the part in strong flexion, from which it cannot be brought without very considerable violence and the infliction of much pain. The posture is, as we have seen, forced upon the part by neuro-muscular phenomena, which, though difficult of elucidation, are, with extremely rare exceptions, constant. Now this flexion, especially if to a considerable degree, is not only a result of inflammation, but it comes to be a cause of its continuance, and is always productive of pain. Moreover, the surgeon, prudently looking to the future, will remember that the disease may get worse; may, exceptionally, however, in mere simple synovitis, pass through various phases of exacerbation until it end in anchylosis; and that, therefore, it will behoove him to place every inflamed joint in or near such a position as will leave the limb most useful. This position is, fortunately, that which is most advantageous for immediate treatment. So important is posture in the management of joint disease, that it certainly is unwise to temporize. If, when the surgeon is called in, he finds the limb in a bad position, and so fixed that he cannot change it by mere traction, without producing severe pain and muscular spasm, it becomes his duty to administer an anæsthetic, and to place the joint in a good position and on a proper splint while his patient is unconscious.

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[1] Though most chronic inflammations must be likewise so treated, yet as there are certain exceptions, the word "chronic" is omitted in the text.

But certain joints are, if they are to be anchylosed, most useful when flexed; others, when straight or nearly straight; and it fortunately happens that these particular postures are those that are best for curative treatment. Therefore each joint has its own angle for fixation, both for treatment and for use.

The *shoulder* should be placed so that the elbow lies a little in front of the median plane of the body, and a little separated from the flank, while the hand may be supported against the thorax of the sound side. A wedge-shaped cushion, which goes by the name of Stromeyer,[1] may be used for this purpose; or, since that is rather liable to slip, two pieces of wood may be placed together in a V shape, inverted, and retained by a metal bracket. One of these is to lie upon the side, the other supports the arm; this latter is to be about three or three and a half inches broad, and is to reach from the borders of the axilla to the inner condyle. The other is to be of the same breadth above, but may gradually widen towards its lower end. To use it, place it when well but not too thickly padded, with its apex in the axilla; bind, by circular turns of a bandage, the one part to the chest, taking care that the other leg of the V shall be in the desired position, and that one or two turns of the bandage shall run from the angle, across the chest and back, to the sound shoulder. When this first portion is well secured, lay the arm on its appropriate part of the splint, and bind it in its place.[2]

The *elbow* is best kept at a right angle, the hand so placed that the thumb lies upward. For this joint a moulded splint of poro-plastic felt, or of leather, is preferable to a flat one of wood. It may be applied either to the inner or outer side.

The *wrist* must be kept straight; an ordinary "dish" splint answers the purpose sufficiently for this sort of case, but a thick pad is to be placed under the palm so as to allow the fingers to be slightly flexed.

The *hip* too must be kept straight, and should also be slightly abducted. The unfortunately common affection known as hip-disease will be discussed in another part of this article; but it is necessary to remark here that that disease very rarely begins in acute synovitis, which is usually a much milder affection, running its whole course, under good treatment, in about ten days. When the surgeon is confident in his diagnosis of a mere synovitis coxæ, he may rest content with placing his patient on his back in bed, and employing weight extension, as in cases of fractured thigh.

The *knee* must be placed nearly straight, and the foot a little in flexion; theoretically, a perfectly straight joint would be preferable, but practically that posture does not avail, because it very soon becomes painful, and because the strain on the Winslow's and posterior crucial ligaments keeps up the inflammatory irritation. As to the sort of splint to be employed, many different opinions prevail. Some surgeons, more especially in Germany, prefer the immediate use of some immovable apparatus, such as plaster of Paris, water-glass, or gum and starch. I prefer, for many reasons, a removable splint, and in my own practice have found that known as the Amesbury splint to answer well. This consists of two metal gutters, one for the thigh and one for the leg, hinged together, and having behind a screw to change the angle. There is also a footpiece, which can be brought nearer or farther from the hinge according to the length of the patient's tibia; its angle, also, can be changed. It is important to make sure that the back of the joint does not lie a little off from the splint, so as to allow, for instance, the easy introduction of a finger into the popliteal space. I have seen many a limb rest on or about the middle of the thigh, the calf, and the foot, while the joint has not been fairly on the splint; the rest under such a vicious arrangement is very imperfect, and much pain, generally attributed to the disease, is in reality due to the defective treatment.[1]

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[1] See Figs. 260, 261. Vol. II., page 158.

[2] In cases of obesity, and also in very thin subjects, it is better not to let the two boards quite meet, but to keep them nearly or quite an inch apart at the apex of the splint; there must then be two metal brackets, one at each end.

The *ankle*, when inflamed, should be so placed that the foot is at a right angle with the leg, and care must be taken that the former does not roll either inward, or, what is more usual, outward, so that the weight falls on either lateral ligament. If the disease be pretty severe, the knee also should be immobilized, otherwise the plastic-felt, or leather splint, moulded to the outer side of the leg, is sufficient.

The cause of my preference for removable apparatus is that it gives opportunity for local treatment, which is prevented by the use of plaster of Paris, or other such means as cover in the joint. Concerning local remedies and their value, there is considerable difference of opinion and of practice in different parts of the world, since varieties of habits and surroundings produce in our patients conditions and states of body essentially unlike. This remark applies more especially to the desirability or otherwise of *topical bleeding* by leeches or the cupping-glass.[2] To justify any local loss of blood as a remedy for joint-inflammation, two conditions must be coincident: one a severely acute, local inflammation, the other a sthenic constitution. But though the coincidence of these may justify blood-letting as productive of no injury, we must also ask ourselves if it will do good. Now, though I only use this remedy in severe cases, and most generally in those of traumatic synovitis which have come under treatment while the disease is yet developing, yet I am convinced that in such cases it often retards or prevents further increase, and arrests the disease at the point it has then reached. It is most valuable if the joint be a superficial one, such as the knee, elbow, or wrist. The leeches should not be applied immediately over the synovial membrane, but to a point above, where the larger veins which receive blood from the articulation are near the surface. By the former method, the superficial capillaries merely are uselessly emptied; by the latter, we probably deplete the deeper venous radicals, those vessels, namely, in which inflammatory retardation and then stasis of circulation first occur. The time at which this remedy is most useful, is at any period of an acute attack in which swelling, already pretty considerable, is still on the increase, the joint becoming larger, more tense, and more painful. A repetition of bloodletting, or even its employment at a later stage of the disease, is to be deprecated as worse than useless.

A more reliable remedy, and one producing more rapid results, is *evacuation of the joint.* All observation shows that pain is in very close, if not in exact proportion to the amount of tension; moreover, it is to be noticed that while severe sprains or certain partial dislocations are very generally followed by severe synovitis and distension; yet complete luxations, accompanied as they are by laceration of the synovial membrane, although more severe, are not accompanied by any synovitis. The inference is fair, that accumulation in, and distension of, the joint cavity by the hypersecretion, is that which prolongs and gives severity to the disease. This distension also, if allowed to continue, is followed by certain evils, such as laxity of ligaments and of periarticular tissues, that render the part for a long time weak and painful; and therefore, for many years past, it has been my practice to puncture and empty all acutely inflamed joints, when distension has been marked. For this purpose, a sharp, tubular needle (an exaggerated subcutaneous-injection needle) is all that is necessary;[1] but, for precaution's sake, an India-rubber tube of $\frac{1}{4}$ inch capacity and about three feet long, may be added. The mode of performance is this: an elastic-webbing bandage is to be lightly rolled on the knee, leaving between two turns the part to be punctured, which of course will be salient. Here the needle, clean and purified by immersion in carbolic oil, is to be thrust in by a quick, dexterous stab, and pressed well home into the cavity. I have very often done this without any tube, believing that the pressure of the elastic band would quite prevent the possibility of the entrance of any air; nor have I ever had reason to distrust the method. Nevertheless, if extra caution be desired, a tube as above described may be secured to the collar of the needle, and filled by suction with a four-per-cent. solution of carbolic acid. This tube is held a foot or two above the level of the joint, and, after puncture has been effected, is gradually lowered, letting its lower end be received into a vessel containing the same solution; or, taking care to avoid any sharp bend, its end may be kept a little raised, so that always some fluid remaining in the tube may act as a trap or valve against any possible admission of air. By this means, we may draw from a knee, from four, even to six ounces of fluid; from a shoulder, from two to three; from an elbow or an ankle, two ounces is a large quantity. But it may be that, though the evidence of fluid in the joint cavity is complete and conclusive, yet none will flow through the needle on account of its viscous nature, or from the canula becoming clogged with flocculi; under these circumstances, a suction-vacuum may be applied, though it will not often be successful; it is better to withdraw the needle, and, passing into the same puncture a fine tenotome, to make in the synovial membrane a pretty wide subcutaneous incision, whereby the excess of fluid soon drains away into the neighboring tissues and leaves the hitherto distended joint empty and flaccid.

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[1] Other forms of splint will be mentioned hereafter.

[2] The cupping-glass has, at all events in London, fallen into almost complete desuetude. In the earlier days of my professional life, that is, about thirty years ago, several persons in the metropolis made very good incomes simply by cupping; a considerable portion of their practice was in cases of inflamed and injured joints.

The result of this evacuation is immediate and strongly marked. Tension, of course, ceases at once, and pain very rapidly, sometimes immediately, disappears. Thus the chief symptoms of synovitis vanish, though it can hardly be that the inflammation itself is so rapidly subdued; but the chief cause of its severity and persistence having vanished, its subsidence, as a rule, very soon follows. I have known cases in which the swelling, to a certain extent, returned; in such, the amount of fluid in the joint is usually very small, and the tension *null*. In a very few instances the synovial sac has filled again, tension has returned, and the evacuation has been repeated; but I have never had occasion to resort to this procedure a third time.

Another remedial resource is *extension* of the limb,[2] that is to say, subject-ing the diseased joint to a certain traction in the downward (anatomically downward) direction, either by means of weights or other force. It will not be necessary to describe the various modes of applying extension here, since the method must be more fully referred to in the section on chronic inflammations, where it is, in my belief, more useful than in the acute forms of disease. Nevertheless, it must in justice be pointed out that many writers of great authority—Volkmann, Langenbeck, and others—speak in high praise of extension as a direct antiphlogistic, and that they, like many others, consider that the secret of its virtue lies in enlarging the cavity of the joint, and thereby diminishing intra-articular distension. But this supposition is evidently incorrect; the only way in which extension could enlarge a joint cavity would be by drawing the bones asunder, that is, by elongating the ligaments. Acute synovitis, if considerable intra-articular distension be permitted to continue, leaves behind a very detrimental laxity of ligaments; if to this were added such powerful extension as would elongate them, still greater trouble would follow. Too powerful extension may be, and, as I have observed, has been, followed by such an injurious result. But such moderate traction as is ordinarily employed, does not increase, in fact, it rather decreases the joint-space, by causing a certain tension of the skin.[1] My own belief is, that the value of extension is to be found in its resistance to the morbid muscular contractions to which I have already referred. Muscular effort, whether voluntary or involuntary, may always be tired out by continued resistance, and, if this resistance be of a sort insusceptible of fatigue, it must, in a certain time, obtain the victory. We shall see, hereafter, that the obstinacy of many joint inflammations is in great part due to the excessive mutual pressure of surfaces, produced by the muscular contractions. If we overcome these, we in so far place the part in a better position for getting well. The indication, therefore, for the use of extension is not the fulness of the synovial sac, but the advent of well-marked neuro-muscular phenomena, and it may be thus used, whether or not the joint has been previously emptied.

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[1] There is no occasion for the suction or aspirating apparatus of Dieulafoy; indeed it often leads to disappointment.

[2] There is here some little difficulty in nomenclature. The term as thus applied does not mean straightening of the limb, but traction in the direction of its long axis. Volkmann and, following him, many German writers call the method "distraction."

In the absence of these symptoms, we shall probably find that evacuation of the synovial sac leaves a certain inflammatory state behind, and we may then take further measures to subdue this condition. Of these measures, no doubt the use of *cold* is the most potent for all but very deep joints. It must be rather intense; the mere application of water, or of an evaporating lotion, is inoperative, but ice kept on the part for a considerable time has a very decided effect. The easiest mode of application is to place small pieces of ice in a wide-mouthed India-rubber bag, and to suspend it in contact with, and partly surrounding, the joint, from the wires of an ordinary bed-cradle. Probably the first contact, driving blood from the surface, causes some greater fulness of the synovial vessels, but in a little time the deeper tissues also become chilled, and, save in such deep articulations as the hip, the whole membrane, with the peri-articular structures, becomes pale and bloodless. In the use of this remedy, however, some caution is necessary, for in persons about or beyond middle life, and even in young people of rheumatic habit—especially in those who have suffered from acute rheumatism—cold, though at first beneficial, is very apt to leave behind a condition of chronic or recurrent inflammation, and often, even without demonstrable inflammation, a tender and painful condition of the joint, a stiffness and lameness which are very difficult of cure.

In such persons, *heat* is a preferable remedy; it must not be mere warmth, but absolute heat of a dry kind, and of as high a temperature as the patient can bear without pain. But it does not seem to me that its long continuance is of advantage; it may be used, according to its effect upon the pain, for from half an hour to an hour at a time, and may be repeated two or three times in the twenty-four hours. The simplest mode of application is by means of salt heated in a frying-pan, or in the oven, and placed in flannel bags—of which two should be provided, so that a fresh, hot one may replace that which has cooled. I suppose that this application acts as a derivative, for since tenderness of the surface shows hyperæmia of the superficial vessels, it is probable that the deeper parts are correspondingly made emptier.

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[1] I would especially refer those who are curious on this subject to some excellent work by my friend, Dr. Karl Reyher, in the Deutsche Zeitschrift für Chirurgie, Bd. iv. S. 26 und folg.

Blisters or other *counter-irritants* are not advisable during this stage of acute synovitis, but at a later period, when the object sought for, is, as we shall see, different, they may be properly employed.

The treatment above described ought to quite suffice for subduing acute serous, sanguineous, or even purulent synovitis, and will be found efficient for that purpose; but patients of gouty, rheumatic, or even of strumous habit, may receive an injury resulting in synovitis, and the disease, becoming chronic, may, mingling with the constitutional taint, put on the characteristics of gouty, rheumatic, or other such disease. Such subacute or chronic endings of the disease are often unnecessarily prolonged, because the particular habit of body is either overlooked or too lightly regarded; we should always, if not from the first, still very early, consider the possibility of such complications, and we may then have to use, what need not be considered here, the appropriate remedies for these special forms of joint disease.

But even if this do not occur, the *reliquiæ* of a severe attack of acute synovitis may be very lingering and very troublesome. Often, if considerable distension have been allowed to continue for some time, a certain laxity will render the part insecure, with a disagreeable sense as though something might readily slip out of place, while yet the joint is stiff and moves uneasily. Or again, after those cases in which the fluid is less, but the heat well marked—especially after purulent synovitis—there is left very considerable stiffness; every movement is more or less painful, the joint grates or crackles, and after use, as, for instance, in bed at night, it aches and will not lie comfortable in any position. If a little more exercise be taken, it not only is more painful, but may feel very useless, and may even swell again. In these states *counter-irritation* is often valuable. The milder counter-irritants, such as tincture of iodine, nitrate-of-silver solution, and others, may be applied directly over the joint; but stronger remedies, such as blisters, should be placed a little distance away, and generally above the synovial membrane, and, if possible, over the nerve or some of the nerves supplying it. Thus, for the elbow, a blister occupying the inner aspect of the arm, just above the condyle, will do more good than if applied elsewhere; or if we wish to blister the knee, the application should be made above the joint, over the lower part of the internal vastus, because here is situated a plexus between the crural and obturator branches, both of which send twigs to the knee. But I would not advise that blistering be carried far, and I myself prefer to stop short of vesication, repeating often what is little more than the use of a rubefacient.

Another powerful means of causing absorption either of parietal thickening or of remaining fluid effusion, as also of giving firmness to a relaxed joint, is compression. The mode in which I prefer to apply it is either by an elastic bandage or by strapping-plaster, according to certain circumstances. If there be mere weakness with thickening, with no or very little fluid effusion, compression by strapping-plaster is best. The adhesive material may be either simply the emplastrum resinæ or the mercury and ammoniacum plaster of the British Pharmacopœia; the emplastrum calefaciens is sometimes valuable, and the emplastrum plumbi iodidi, save in gouty constitutions, may aid in promoting absorption.[1] The strapping should be cut in strips of about three-quarters of an inch in breadth, and evenly applied from below upward with a certain amount of tightness and pressure. But if there be some little fluid in the joint, it is better at first to use elastic compression; this of course may be done by sundry means, as, for instance, by the elastic caps which are made for all the important joints of the limbs; but I prefer a simple, elastic, web-bandage, which may be trusted to do all the work more evenly and better. It upholds the weak joint, and procures absorption both of solid thickening and of effusion. It should be noted, however, that all such appliances aid in producing wasting of the muscles above the joint, of those which move the lower of its segments, and more especially of the extensors.

Dr. Martin, of Boston, Massachusetts, extols his solid, India-rubber bandage, the use of which "alone" or with aspiration, he says is always curative of "synovitis and its sequelæ, in every form and degree of severity, in every variety of diathesis and complication."[2] By "alone," Dr. Martin means among other things that he does not allow rest of the joint. The observation of the profession at large does not corroborate this experience.

Therefore caution must be exercised, and especially the bandage should not be employed where the limb is much wasted, and it should not be continued longer than necessary. After these various methods have been sufficiently employed, and have had their full effect, the patient may still find considerable difficulty in employing the limb, especially if the inflammation have been severe, and have been in a joint of the lower extremity, whose work is more onerous than that of the upper. To overcome this last remnant of disease is of course a work of time, which may be greatly aided by two procedures—*shampooing* and *passive movement.*

These, more especially the former, are carried out under surgical superintendence by "medical rubbers," the manœuvres being called, in England, "rubbing;" on the Continent, "massage" (kneading); the mere act of rubbing or kneading the part being conjoined with certain movements which the surgeon should so direct that they may affect the most shortened muscles. The rubbing itself should be done with the palm, the ball of the thumb and that of the little finger being chiefly called into play; the direction should be that of the venous circulation, the skin being protected by powdering with flour or starch, or sometimes by inunction with oil; the friction should be energetic, one hand following the other rapidly up the limb; these manœuvres certainly aid in causing absorption of indurations and of thickenings, but I cannot ascribe to them all the somewhat wonderful results that their more enthusiastic advocates claim,[3] although there is no doubt that restoration of form may be to a large extent hereby produced. *Passive movement* is one of the most powerful means at our command for overcoming the stiffness so often left after any form of articular inflammation. I shall, hereafter, describe various modes of carrying out the necessary manœuvres, and will, therefore, relegate to a future occasion what must be said on the subject. Here it need only be remarked, that, as simple synovitis rarely leaves behind any considerable muscular shortening, the surgeon has chiefly to do with thickening of periarticular tissues.

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[1] Gouty persons are most injuriously affected by lead, and they absorb it into the system with marvellous ease.

[2] Transactions of the International Medical Congress. London, 1881.

[3] The prophet of "massage" is par excellence Dr. v. Mosengeil, to whose papers readers, curious in this matter, may refer (Verhandl. der deutschen Gesellsch. für Chirurg., 4ter Congress, 1875), and he describes a number of slightly differing manœuvres which have, in his opinion, very diverse effects.

The *treatment of dry synovitis* must be conducted on somewhat different principles; the very painful nature of the disease indicates opium, and this drug or its derivatives, alone or in combination, may be freely administered, either by hypodermic injection, or as a remedy by the mouth. Nepenthe is, as I have on more than one occasion observed, a very valuable and efficacious preparation. According to the state of the skin and urine, diaphoretics, diuretics, and alkalies, especially ammonia, may be exhibited, and I believe myself to have found some advantage in colchicum, commencing with a rather full dose, and continuing it in smaller quantities. The food should be sufficient in amount (patients have usually fair appetite), but not stimulating; farinaceous articles, fish, and eggs, are better than meat. It is in most cases desirable to allow a certain amount of alcohol, either as wine, or, better still, in the form of old whiskey, given with an effervescent water. I have twice used the portable-lamp vapor bath; in both cases the skin was very dry and irresponsive to the action of internal diaphoretics, and in both cases benefit resulted, the patients enjoying some hours' tranquil sleep.

The *local treatment* must be conducted on the same lines. Rest on or in a well-fitting splint must be enforced; but also I believe it to be of great importance to keep the skin of the part moist and warm. For this purpose poultices, sprinkled with laudanum; or compresses steeped in liquor opii and water, in equal parts; or, again, equal proportions of glycerine and freshly prepared extract of belladonna, are useful. Ease is obtained in some cases by applying very hot fomentations, fresh and fresh stupes of flannel wrung out of very hot water being constantly alternated, so as to keep the one on the part constantly very hot. Cold and counter-irritants, in these cases, are, in my experience, useless if not injurious.

When the extreme pain which marks the early days of the attack has been somewhat subdued, care must be taken that the joint does not become anchylosed, and, with this object in view, it is well to take the limb from the splint, and very gently to move the part. If pain be produced, such efforts must be postponed to some near future; but movement is often quite or nearly painless, and it should then be continued slowly for a few minutes, when the splint must be replaced, the same manœuvre being repeated at intervals. Rubbing may also be advantageously made use of. When the immediate, acute symptoms are subdued, they are not liable to return under such treatment cautiously applied.

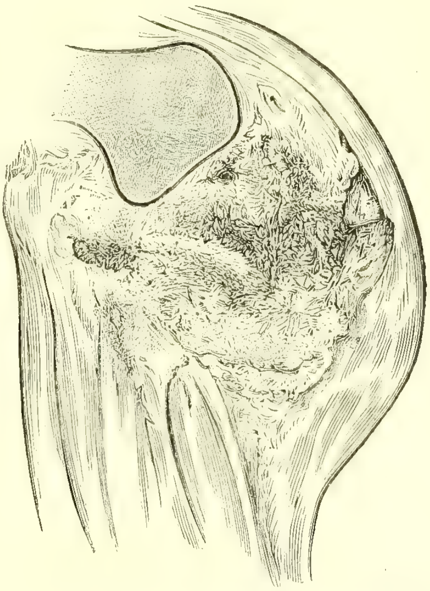
SUPPURATIVE SYNOVITIS.

A joint may inflame and suppurate in various ways; in some instances, and more especially with children, all the structures seem to be simultaneously involved in suppuration. The disease, in such cases, really begins, as we shall see hereafter, in the epiphyseal ends of the bones. Again, pus in the cavity of a joint may originate in pyæmic blood-poisoning, following, for instance, parturition, certain fevers, or urethral irritation. All these cases are to be distinguished from the disease now under consideration, which is entirely local, and which consists in an inflammation, confined at first and for some time to the synovial and perisynovial tissues, running on rapidly to the formation of pus in those parts, and not involving, until subsequently, the harder constituents of the joint.

The most characteristic picture of the disease is usually presented by those examples which follow direct wounds, but equally typical forms may follow other kinds of injury. Histologically, the distinction between *purulent* and *suppurative* synovitis is the greater thickness of tissue involved. In the former, as we have seen, the mere surface of the membrane, and the parts immediately underlying it, are implicated; in the latter, a considerable portion, or the whole, of the membrane and periarticular tissues are disintegrated, softened, and destroyed, in the manner described by Stricker in the article on the Pathology of Inflammation.[1]

I do not purpose here to particularize the minute events of suppurative inflammation, but I must point out what is peculiar to the action on joints. The first perceptible change is redness of the synovial membrane, which, beginning with a slight blush, rapidly deepens into a crimson, and then into a purple hue. It is not uniformly diffused on the surface, but is in blotches of various size and intensity; in some parts, rupture of minute vessels gives rise to chemosis. The redness is not immediately on the surface, but a little beneath a film or fine membrane, which, at first quite transparent, and, as it were, slightly swollen by a serous infiltration, becomes cloudy, then milky in its deeper parts, and, at the same time losing its polish, grows roughened and coarse.[2] Part of this roughening depends in the earliest stages on increased proliferation of the superficial endothelial cells; another part, on falling away in patches of the endothelial coating; a third, on the over-filled vessels making prominences athwart the basement. At a later period, the roughness becomes more marked and coarser. Some of it appears to arise from fulness of vessels and from thickening of their walls; part of it from a surface condition—from little elevations on the superficies, not unlike a coarse, velvety pile. At this time, and more especially afterwards, it is exceedingly difficult to trace further changes; but if an animal thus affected be killed about a week or ten days after the infliction of the injury—or if, in the human subject, opportunity for anatomical examination be afforded—the following condition is observed: An extremely thick fibrin-containing pus, often blood-stained, adheres to the surface after the usual thinner pus has escaped. A portion of this may be washed away by a gentle stream of water, but some material—whether we call it fibrinous pus or fibrinous exudation—mingled with many leucocytes, adheres so firmly, and is so entangled in the roughness of the surface, that it must be helped away and gently detached with a camel's-hair pencil, or even with forceps.[3] When this is accomplished, the inner surface of the synovial membrane is found to be no longer smooth, but to be studded and covered by hypertrophied fringes (Fig. 630), which branch into many ramifications,

Fig. 630.



Suppurative synovitis with fringe proliferation. (From a specimen in the Museum of the Royal College of Surgeons.)

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[1] Vol. I. page 38.

[2] This account is partly taken from experiments related by M. Richet, partly from certain work of my own in the same direction, which circumstances forbid me further to specify, save to say that the object of my research was to study the phenomena of fringe-hypertrophy.

[3] This examination should be carried on under water, a gentle stream flowing into the vessel, and clearing away the opacity caused by the admixture of secretion and débris.

and look almost like a discolored moss, or sometimes like that singular fungus which hangs from the ceilings of old wine cellars. Nor are these beautiful growths confined to those parts of the joint which are normally the seats of fringes; they arise from the whole inner surface of the membrane and hang into the joint, while some, breaking away, float free in the fluid, and, undergoing fatty degeneration and decay, are after a time mere floating flocculi.

The tissues outside the joint, likewise in a state of severe inflammation, undergo the hyperplastic, the indurating, and subsequently the disintegrating processes, so well described by Stricker,[1] which constitute suppuration. These do not, of course, take place equally and simultaneously, save in very severe cases, throughout the whole thickness and extent of the periarticular structures; hence, we find, after a little time, spots of inflamed tissue ready to break down into abscesses, surrounded by parts still comparatively unaffected. Nor does this apply only to the soft tissues; the bones for a certain distance from the joint become inflamed, but after and more slowly than the other periarticular tissues, and in this inflammation the cartilages of incrustation participate.[2] If a joint in these stages of disease be removed from the body, and split so as to show in section the interior of the bones, the edges of the cartilages, and those of the synovial membrane and its surroundings, together with the interior of the joint-bag, we find that the latter, instead of being an empty cavity, is occupied by proliferating fringes, looking, as they slightly protrude, like strings of beads or bunches of millet. Outside this, is a district of more or less red, gelatinous material (proliferating areolar and ligamentous tissue). This jelly-like substance, or, as I have called it, granulation-tissue, is traversed by white fibrous cords—that is, by those parts of the capsule which may still remain unchanged, and which are more or less abundant, according to the age of the inflammation. In some parts the new inflammatory grow this evidently breaking down, is perhaps deeply stained by some extravasation; in other parts less metamorphosis has taken place. The section of the bones lays the cancelli and their cavities bare. If the stage of inflammation be still quite early, those spaces will simply be found hyperæmic, and from them some blood-stained serum will exude. At a later period, the exudation will be thicker and yellower; and at one still later, the redness of hyperæmia will be concealed by the creaminess of pus and of exuded fat globules. When this fluid is washed away by a stream of water, one may see that out of each cancellus protrudes a little bunch of inflammatory new growth (due to proliferation of its lining membrane), which before section was compressed within the cavity. After section, the tissue projects so that when the finger is lightly drawn over the surface merely a soft material is felt. If, in going further, this granulation-tissue be removed, we find the cancellar walls variously changed, according to the mode and stage of the inflammation—viz., where the action is more intense and older, their lamellæ are softened by loss of earthy constituents, are thinned by absorption from both sides, or have disappeared. In places where the action is less severe and newer, the indurating phase may be found, the walls being thicker, and the cavities smaller. The softened or disintegrated parts are, unless the action be intense, distributed in spots here and there, and are more or less surrounded by the indurated portions, which, therefore, on section appear as circles, or segments of circles.[3]

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[1] See Vol. I. p. 30 *et seq.*

[2] Inflammation of cartilage precedes, by periods variable in duration, any breach of substance; a certain change of hue, then dull-white opacity, and subsequently easy impressibility with the finger-nail, and fibrillation, are the macroscopic signs of this condition.

[3] More detailed account of these processes (termed *osteosclero is* and *osteomalacia*) will be given on a subsequent page.

Thus it is to be noted that different phases of pathological conditions exist: 1st. Inflammatory hyperæmia and exudation. 2d. Proliferation and cell infiltration. 3d. Inflammatory induration. 4th. Inflammatory disintegration and formation of pus (tissue-pus, not mere surface secretion). At any point previous to the last, there is still the possibility that retrogression may occur, or be induced, and that the joint may be cured with no or but slight impairment of function; even when the last of the above phases has set in, but before much tissue-destruction has occurred, cure with a certain restriction of movement may often be effected. The restriction depends upon the cicatricial-like healing—the contraction and hardening of previously disintegrated tissue—and its amount therefore is commensurate with the area of the destructive action.

When the bones have suppurated and the cartilages have given way, the cure, if attainable at all, must be by more or less anchylosis, false or true. To explain this, we must return to the onward course of the disease from the point at which we left it—namely, with the joint-cavity full of pus, and with the periarticular tissues occupied by abscesses, or by disintegrated spots ready to break down into abscesses. If the inflammation continue, the altered synovial membrane becomes ruptured or perforated in several places, the pus of the joint-cavity mingles with that of the abscesses in the vicinity, or, being effused into non-suppurating surrounding parts, excites in them pus formation. Both around and in the joint, therefore, destructive action is set up, and abscesses are found in the cavity, in the immediate neighborhood, and, in the worst cases, extending a considerable distance up and down the limb. I am in the habit, in my lectures, of distinguishing these as intra-articular, peri-articular, and adjacent abscesses.

About this time, if not previously, the cartilages become ulcerated, chiefly and most rapidly in the locality of greatest inflammation, that is, in the neighborhood of fringes, which soon mingle with the cellulo-fibrous, cartilaginous débris, in a manner which suggested the erroneous idea, formerly entertained, that the fringes, as it were, eat holes in the cartilage,[1] which was regarded by most authors as an entirely passive and inert material. Instead of, or in combination with, this mode of cartilage destruction, another series of events may occur; for, if the absorption of cancellous lamellæ by coalescing granulations (see preceding page) take place on a rather wide area immediately next to the articular lamella, that plate of bone gives way, and, together with the incrusting cartilage, is pushed by the new tissue into the joint, or rather, in advanced cases, into the confused mass of proliferating fringes and granulation-tissue, which then occupies the joint-cavity. Frequently we find such portions lying detached, or partially detached, with the deep surface rough and gritty, like sand-paper, in consequence of adherence of the disintegrated articular lamella. In either way, the interior of the bone-ends and the area which previously was a joint, coalesce into an inflamed, granulating mass, in which are found the larger or smaller remains of ligaments, capsule, synovial membrane, and cartilage, more or less destroyed by and merged into the new elementary tissue. In the centre is still, in all probability, a cavity partially filled with pus and tissue-débris. This cavity is usually surrounded by others formed by inflammatory disintegration in the substance of the new growth, and these may communicate either with the central space or with the outer air, or with both; they may also extend a considerable distance from the original seat of disease, as just described.

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[1] For an account of the inflammatory nature of cartilage-ulceration, see my work on Diseases of Joints, 2d ed., p. 339; American ed., p. 269; also, Prof. Stricker's article, in this Encyclopædia, Vol. I. p. 38.

While the joint itself is undergoing these transformations, and, indeed, from their early beginning, the neuro-muscular phenomena already mentioned (p. 264) are in great activity, and no longer as merely tonic, but now also as clonic spasms. I pointed out, more than twenty years ago, that the irregular spasms of muscles called "starting pains," coincided and were intimately connected with that hyperæmia of the bone cancelli immediately underlying the articular lamella, which accompanies cartilaginous inflammation. The more potent this blood-fulness, and the more acute the inflammation, the more fully are these spasms, as well as the less irregular muscular contractions, developed. The effect of such forces upon a joint whose ligaments and bone surfaces are altered in the manner above described, is evident, viz., more and more tendency to greater, and even to abnormal flexion, and marked disposition to luxation, or partial luxation, which usually occurs towards the flexor side, but which sometimes is lateral. Their effect on the cartilages, of hastening their ulceration by excessive pressure, has already been mentioned; their influence in keeping up inflammation will be discussed in the next section.[1]

Now if curative acts set in, they will proceed by gradual but often pretty rapid fibrillation of the granulation-tissue, which, hardening, squeezes pus from the abscesses, which then become filled with new elements. Yet, as we found that the interior of the bones, and the articular and peri-articular tissues, were all conjoined or matted together by inflammatory products, so when these consolidate and become fibrous tissue of the cicatricial type, it must happen that the parts become all bound together by a kind of ill-formed ligament—that is, are united by *false anchylosis.* If the changes go still further, the fibres become converted into bone—that is, the union is by *true anchylosis.*

On the other hand, if no reparative processes take place at all, suppuration extends further and further, and becomes more and more abundant. It involves not merely the soft parts, but the bones, producing *caries*, or *caries necrotica*, and the pus, passing beyond the spongy portion, invades the medullary canal and medulla. Meanwhile the constitution breaks down, either by way of pyæmia, of hectic, or of lardaceous change. Amputation, when feasible, now becomes the only chance of saving life.

Symptoms of Suppurative Synovitis.—Although it is very rare that suppurative follows upon acute, simple synovitis; yet any considerable change occurring during that milder disease, any strongly marked pyrexia, especially if preceded by rigors, should cause us carefully to watch for such a sequence. Ordinarily, the disease now under consideration begins at once with the characteristics of suppuration, but of course the diagnosis is much facilitated, if a wound or indeed any other severe traumatism, has preceded the attack.

Very severe pain in a joint, preceded or accompanied by rigors, a sense of depression and illness, and fever with a high temperature, is rapidly followed by swelling. The kind of *swelling* differs somewhat from that of a simple synovitis; the signs of fluid in the cavity are quite evident, but the surrounding soft parts are also swollen and doughy, and in the worst cases slightly œdematous, and pitting on prolonged pressure. At first noticed merely over

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[1] Bonnet, of Lyons, believed that the flexed position was forced upon the limb by the mechanical influence of the distended synovial membrane, and he instituted a number of ingenious experiments which he erroneously imagined proved that contention. The truth is, that joints, when violently inflamed, assume often such positions as greatly diminish the area of the synovial cavity. Moreover, when the cavity has been evacuated by art or by disease, the position is still maintained, or goes on increasing; while, on the other hand, change of posture has marked curative effects which it could not possess, if, the synovial area being diminished, the tension were increased.

the joint, after some time the limb-segment below participates in this œdematous condition. The skin, save over deep joints, is somewhat reddened; not uniformly, but in parts corresponding to the place of the absorbents, or of the larger veins; between these pink parts the skin looks white, and subsequently sodden. If there be an open wound into the joint, it assumes a peculiar look; the orifice from which synovia flowed becomes dry; the granulations, if any have formed, become pale and shrivelled, or if none have arisen, the raw edge of the wound becomes livid and foul.

In from two to five days, according to the violence and rapidity of the disease, contraction of muscles (exaggerated tonicity), causes *malposture*[1] of the joint, which is always towards the side of flexion, and at first is merely a morbid fixity. Very soon, however, clonic spasms, also called "starting pains," are superadded, and with them the position of the limb may become in itself abnormal—flexion may overstep the natural limits, or some subluxation may occur. In the mean time the muscles affected with these spasms waste very rapidly, the limb-segment above the joint more especially shrivelling very quickly. This wasting is often mistaken for additional swelling of the joint, which, lying between two shrivelled parts, naturally appears larger. Measurement will correct this impression.

After a few days the form of the *fever* somewhat changes; it was at first, though high, yet moderately uniform, but it now becomes, sometimes sooner sometimes later, very uneven, the chart marking large variations. In the mean time the tongue becomes furred, and the pulse small and weak.

At this point the surgeon, seeing the patient for the first time, has many difficult points of prognosis to consider, and on them to found his treatment —whether to aim at restoration, or at more or less anchylosis. Unfavorable signs are a more or less œdematous state of the limb below, a dry furfuraceous skin, patchy redness over the joint, with a network of large veins on its surface and meandering up the limb, and progressive aggravation of symptoms, both local and general. Nevertheless, in order to arrive at a sure view, it is desirable to give some anæsthetic, under the influence of which a more complete but a very gentle examination may be made. By palpation, the amount of fluid in, and the distension of, the synovial membrane may be estimated, and the presence and situation of surrounding abscess, as also the presence or absence of bony enlargement, may be determined. Then the joint may be gently moved, while the following points are especially noted: Whether the one bone moves upon the other without crepitus; the presence of that symptom shows of course that ulceration of cartilages has taken place, though its absence does not connote the contrary, since in such ulcers the bone beneath is often protected by granulations. Whether the lower limb-segment moves upon the other in its normal area and sphere. Whether any abnormal mobility be present, as, for instance, a lateral or antero-posterior gliding of the ulna on the humerus, or of the tibia on the femur. A negative to all these queries would go far to induce a favorable prognosis, and strenuous efforts to preserve the joint.

In its further continuance the disease may still remain acute, abscesses pointing or tending to point in various parts, either immediately over or but a short distance from the joint,[1] and the limb becoming more and more bent; distortion, either from subluxation, or, in young subjects, from diastasis, frequently supervenes, exfoliations may occur, or bare, crumbling bone may be felt with the probe. In some cases fragments of the cartilages come away in the discharges. All through this course of events, the patient's suffering is severe; he eats and sleeps but little, sweats profusely, and emaciates rapidly; the fever, which at first was sthenic, becomes of an asthenic or typhoid character, and, if he still survives, hectic. The fatal issue may be from pyæmia, from exhaustion with lardaceous changes, or sometimes from a rapid form of tuberculosis.

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[1] I use this word in a perhaps rather unusual sense; thus, the position of a limb may be in itself abnormal, or, being normal, may be only faulty in its fixity; *e. g.*, a knee bent at a right angle is not faulty as to its position, which is one that healthy knees assume many hundred times in the course of a day; but if that posture be more or less fixed, so that the individual does not or cannot move it out of that angle, this is *malposture* by fixity, even though the surgeon may with very little power alter the angle. To this fixity may, or may not, be added abnormity in the relations of the bones to one another, or flexion may simply be carried beyond the natural limits; here malposture by position is added to that by fixity. But when the word "malposture" is used alone, I intend to denote either one or the other, or both together; it is a general, abstract term, the more convenient that it does not particularize.

If, on the contrary, the disease be about to improve, one of the earliest signs will be a lower and more even temperature; the pain becomes less, the sweatings cease, the discharge gradually diminishes, the abscesses contract to sinuses, and, the granulations receding from their mouths, these one after another heal, leaving depressed, sometimes greatly depressed, scars, while the abnormal mobility gives place to more and more fixity. If the subject be young, it will be observed, when the joint has healed, that the ends of the bones are smaller than on the other side; not, perhaps, immediately on recovery, but soon after, and at the same period the limb will be found to be shorter than its fellow. After a severe attack of suppurative synovitis, the growth of the epiphyses ceases, as also does the longitudinal growth of the bones from the epiphyseal cartilages adjoining the articulation. This fact must never be overlooked in our prognosis as to the future condition of the patient; it is of course less important in the upper than in the lower limb.

TREATMENT OF SUPPURATIVE SYNOVITIS.—Penetrating wounds of joints are not necessarily followed by suppuration; but they should always be treated with reference to its possible occurrence. I have been till lately in the habit of thoroughly washing, and even injecting, all such wounds with a warm solution of carbolic acid, of the strength of three or four per cent. Of late I have used the boro-glyceride of Professor Barff,[2] one part in twenty. I have found it better, inasmuch as it is not irritating; one may fill the wound, and the joint itself, with such a solution, without fear of producing any inflammation by the contact of the fluid. At the same time, any dirt or other foreign substance should be carefully removed, and then the limb should be placed on a splint that keeps it at perfect rest. I prefer apparatus which can be removed, since plaster of Paris, starch, or water-glass, may have to be cut away, if inflammation and swelling come on, at a time when every movement of the limb is both exceedingly painful and injurious. The wound should then be covered with several folds of lint or wool, soaked in the boro-glyceride solution, and a simple aperient may be judiciously administered before the patient is left. The treatment, should the joint suppurate, will be the same as in non-traumatic cases.

A brisk, cholagogue purge should, as soon as the premonitory symptoms appear, commence the treatment; then, according to the strength of the patient and the mode of thermometric rise, such remedies as are antipyretic. A large dose of quinine (10 or 20 grains), followed by frequent smaller doses, may be given to the more weakly patients with rapid pyrexial rise; in other cases, the tincture of aconite, from one to three drops, every hour, or every two hours, will be preferable; again, in others, the citrate or acetate of ammonium. Some form of opiate will be necessary; it is best given hypodermically (morphia), or as a suppository, and may often be combined advantageously with belladonna or atropine. Other drugs, such as digitalis, potassio-tartrate of antimony, or ipecacuanha, may have their applicability in certain cases. Alcohol is often desirable after the first few days, and, if the disease be long-continued, becomes a necessity.

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[1] Acute suppurations come to the surface usually by a pretty direct route; chronic abscesses are more usually turned aside by intervening fasciæ, and, therefore, take circuitous courses and make long tracks.

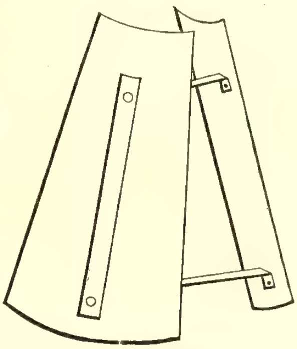
[2] For the use of "boro-glyceride in operative surgery," see the Lancet, May, 1882, and my paper read at the Warwick Meeting of the British Medical Association, August, 1882.

In the *local treatment*, the first consideration is *rest in a good position;* that is to say, if, on his first visit, the surgeon should find the limb in the posture which he would desire, a well-fitting splint should be at once applied; but if a bad position should have already been assumed—and sometimes this takes place very rapidly—an anæsthetic should be given, and the right posture restored. When the disease is still moderately recent, no force will be required; indeed, if placed so that its weight acts advantageously, the limb will of itself assume the desired position. During anæsthesia, the necessary splints should be applied, and, unless the disease be either in the shoulder or hip, the limb should be swung: the upper extremity by means of pulleys and counterpoise; the lower, by the Salter cradle.

A double object is gained by the restoration of the joint to a proper position: first, the patient's sufferings are markedly diminished, while the violence of the disease is often cut short; secondly, if, in the subsequent course of events, anchylosis is to occur, the limb will be in the posture most available for use. Thus, the shoulder must be so placed that the elbow, a little separated from the side, lies slightly in front of the lateral median line; the elbow must be placed at a right angle; the wrist straight; the knee not quite, but very nearly straight; and the foot so that its long axis is at right angles with that of the leg.[1]

When the symptoms show that suppuration is, or is about to be, present, the appliance to be used becomes a matter of very great moment, the simple retention of the limb in a plaster-of-Paris bandage being no longer suitable. The joint must be kept at perfect rest, and yet must be accessible.

Fig. 631.



Splint for shoulder.

The *shoulder* may be bandaged to the side with simply the intervention of a wedge-shaped (Stromeyer) cushion, or, which I prefer, a splint in two parts, both of poro-plastic felt; one part is, for the adult, 9 inches broad at the lower part, 5 inches at the upper, and is to be moulded on the side of the thorax, reaching to the axillary folds; the other, about 4 inches broad, is moulded on the inner side of the arm. When dry, these pieces are removed, and are then joined by riveting through them two brass rods, the higher one so arranged as to keep the upper ends of the splint about one inch asunder, while the length of the lower rod is to be fixed according to the distance at which it may be desired to keep the elbow from the side.

The *elbow* is easily fixed. I prefer a splint made of two metal gutters, the length of the upper arm and forearm respectively, each gutter having projecting at one of its ends a broad tongue of the metal, in which is a hole to receive a clamp-screw for fixation. The portion for the forearm, when cut, is of the shape here given (Fig. 632, *a*). That for the upper arm is broader, and without the hand-piece, but has a similar tongue. When shaped, the splint is formed as at *b*; but the portions must be at right angles with each other. The arm should be swung in a double sling, with counterpoise.

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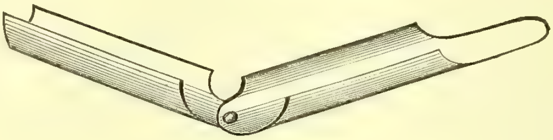
[1] Diseases of the hip being in certain points peculiar, their consideration is relegated to a subsequent page.

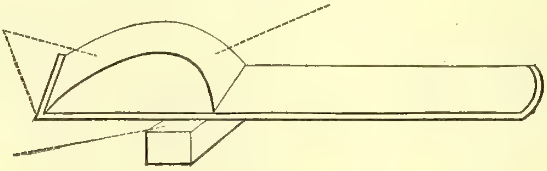
Fig. 632.



Splint for elbow.

The *wrist* may be treated on a simple, straight, or dished, hand-splint; or, better, upon that used for wrist excision, taking care fully to support the fingers and the thumb.

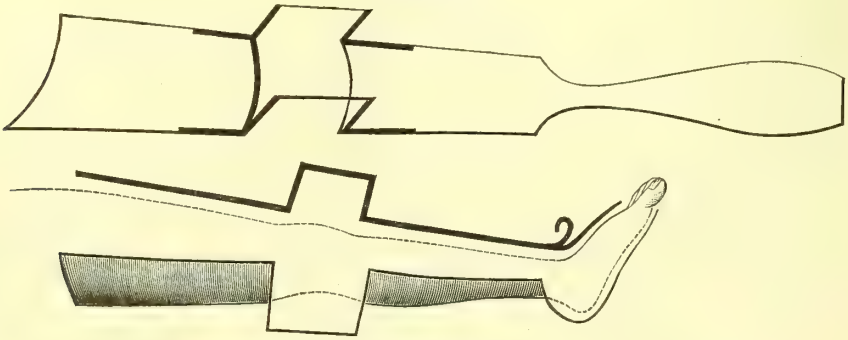
Fig. 633.



Splint for wrist; the hand to rest on the cork addition.

The *knee* may be treated on a MacIntyre splint, properly slung; but useful as this appliance is in simple synovitis, it is not equally commendable in this more serious form of disease, partly because the structure is too hard, partly because the support is insufficient. Of late I have cured two severe cases of suppurative synovitis—the one by anchylosis, but in the other preserving a considerable amount of mobility—by means of the splint which

Fig. 634.

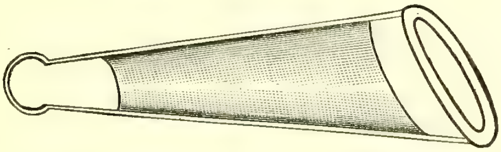


Splint for knee.

some years ago I devised for the after-treatment of knee-joint excision. It consists of two metal gutters, one for the thigh and the other for the leg and foot, fastened together by two steel-wire brackets that stand well away from the back of the joint; with a round, steel rod passing from the groin to the end of the metatarsus, but bent bracket-wise as it passes over the knee. These splints, being held in position, are secured in their places by plaster-of-Paris bandages, applied with sufficient firmness to the thigh and to the leg and foot, omitting the knee altogether, which thus remains exposed all around for treatment.

Thomas's knee splint is of good construction; but its fault is that it covers all the back and a considerable part of the sides of the joint, which cannot be well got at to make incisions or for other purposes. It consists of two round metal rods united below the sole, or, if small, of one rod bent upon itself so as to make a loop under the foot while the segments run up on the inner and on the outer side of the limb respectively; the inner is a little shorter than the outer branch, so that when they end in an oval metal ring it lies upon them at an angle of 45°, thus fitting the perineum and tuberosity of the ischium, on which it chiefly abuts, as also the groin and outer face of the ilium. Furthermore, there is loosely stretched between these rods a strip or apron of leather, on which the limb is to rest, the apron being slit on either edge in two or three places for the passage of a bandage.[1] Mr. Thomas also advises that in bad cases a couple of wheels connected by a slotted axle should be used; into the slot the loop of metal under the foot is to be inserted to keep the back of the limb from the bed; but it is far better to sling the whole apparatus.

Fig. 635.



Thomas's splint for the knee in the recumbent position.

The inventor claims for this that it perfectly and entirely immobilizes the joint—an assertion which my experience leads me very much to doubt; there is always a certain play between the edge of the apron, to which the limb is attached, and the irons. Moreover, the irons themselves are too much in the way of the surgeon, the joint having to be treated while lying in a sort of ditch. A great part of these objections might be overcome by bending out, bracket-wise, the two irons, opposite to the knee, and making the leather apron in two parts, one for the thigh and one for the leg, omitting the part behind the knee altogether.

The *ankle-joint* may be fixed in sundry ways. In severe cases, the lower part of the splint for the knee (Fig. 634), with a plaster-of-Paris casing, omitting the joint itself, is the steadiest and most secure. But a simpler splint may be made by moulding to the leg and foot, including the sole, a piece of poro-plastic felt. This must more than half encircle the leg, and must take in all the heel, the side, and the sole of the foot, as far as the root of the toe (inner or outer). If greater security be thought desirable, such an appliance may be made in two portions, one for the inner and one for the outer side of the limb. When dry, the felt is to be removed, and a couple of interrupting brackets (previously prepared) riveted so as to stride over the ankle; the part of the splint included in the gap of the brackets can then be cut away. The limb should always be slung by a Salter's cradle.

Whatever form of splint be preferred, I would point out that, in this disease, entire immobility is one of the great essentials, while the other, perhaps hardly less important, is accessibility to almost all the joint surface, permitting, if necessary, thorough examination day by day; otherwise, accumulations of pus may very easily escape notice, or, if perchance found, can hardly be treated save by removing the splint, which is a painful and injurious process. The apparatus should be at once prepared, and as early as possible applied, when symptoms threatening suppuration have been recognized; but if it be evident that pus has not yet formed, its production may sometimes be checked by using a strong revulsive, such as a very strong tincture of iodine (60 or 80 grains to the ounce of absolute alcohol), or the actual cautery. The resulting inconvenience, if this does not effect the desired object, causes me to recommend the method only in exceptional cases. A sharp degree of cold, amounting almost to congelation, is more advisable; it may be obtained by either a bladder or bag containing powdered ice, alone, or mixed with a little salt. The mere momentary application of such a remedy is valueless; it must be maintained for a considerable time. Should we, on the contrary, find the joint fluctuating and tense, and yet be led to judge, by the character of the pain and by the amount of pyrexia, that the fluid is possibly not pus, subcutaneous incision (page 274) will give great relief, and is that treatment which is most likely to result in cure. Nor, even if the fluctuation be produced by pus, need we fear the effect of letting this liquid lie in the periarticular tissue: if the disease recede, it will be absorbed; if it continue, an abscess outside is preferable to one inside the synovial sac.

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[1] Thomas, On the Treatment of Hip, Knee, and Ankle-Joint Disease.

But it must be understood that in the last sentence I refer to cases not yet fully developed—to cases in which it may still be doubtful if pus have as yet formed. When, on the other hand, all the symptoms point to acute abscess within the joint cavity, if it be increasing and the surface veins strongly marked, more vigorous measures are safer. Incisions into the joint should at once be made,[1] so freely as to give unobstructed exit to the pus; this ought to be done in such a manner as to prevent putrefaction. For some months I have given up carbolic acid and the spray, the complicated dressings, etc., of Prof. Lister's method, and have found that abundant syringing of the cavity with a 5-per-cent. solution of boroglyceride, and dressing with the same, is safer, and quite as efficacious. The choice of place for the incision or incisions may safely be left to the anatomical knowledge of the reader, and it must also be guided by observing the point of greatest fulness, and also by the position of the joint, for the opening should be as low as possible, so as to permit of the best drainage attainable.

Having secured these great essentials of treatment, good position, entire rest, with support and thorough drainage, the rest of the treatment closely resembles that of any other deep abscess. The cavity must be syringed or irrigated, day by day, with a cleansing and antiseptic solution, and great care should be taken that the drainage tubes are free and pervious; also, the joint must frequently be examined lest any fresh abscess form and, unsuspectedly accumulating, burrow up the limb. Especially careful must be the search, of course without disturbance or motion of the part, should the thermometer rise again. If the pus have been fully evacuated by the first incision into the cavity, the thermometer will fall from 102° or 104° to only a little above normal. If at any time it rise, not suddenly, but gradually for several days, there is in all probability retention of pus, which must be let out, even though it lie extremely deep. If the thermometer remain steady between 98° and 100°, pus is not likely to be forming afresh, but in all probability the joint is going through the various healing processes favorably and well; that is to say, the part which has suppurated, be it larger or smaller, or be it the whole joint, is getting repaired by the act of granulation, during which the surgeon must watch for fragments of cartilages which may be shed, and, coming forward towards the abscess-opening, may obstruct, until extracted, the due outflow of pus. Thus he must guide the patient through the dangers inseparable from deep abscess close to and between bones; he must watch the behavior of the pus, guard against the tendency to burrow, especially upward, along and close to the bone; especially must he watch the general condition of the patient in the first part of the case, considering the danger of pyæmia. Afterwards, and when the suppuration has gone on for a lengthened period, hectic, and especially the evidence of lardaceous disease, must be looked for. Amputation will sometimes be the only means of saving life.

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[1] This treatment had fallen into disuse since the times of its early advocates, Petit and afterwards Boyer; it was revived by Mr. Gay. (Med. Times and Gazette, vol. xxiv. p. 546.)

But when these dangers do not arise, or having arisen have been successfully combated, the local processes will duly complete themselves; the pyogenic and granulation tissues will have become consolidated into a fibrous mass, a sort of cicatricial tissue. The surgeon may now by his treatment conduce to the anchylosis becoming true, or he may keep it false. As a rule, it is better, in the upper extremity, to aim at the latter event, by the use of passive motion more or less vigorously applied according to circumstances. At the hip (in which joint suppurative synovitis is a very rare and very fatal disease), any slight mobility is a great boon, but is difficult of attainment. At the knee, much depends upon the following circumstance: If there have been abnormal mobility, especially lateral mobility, it is best to permit true anchylosis, lest a loose or flail-like joint result. Slight mobility at the ankle is desirable, but the bones of the tarsus acquire such considerable mobility among themselves, as greatly compensates for an entirely stiff ankle should true anchylosis occur.

Synovitis from Absorption of Morbid Matters.

The above forms of synovitis, viz., simple, sanguinolent, purulent, dry, and suppurative, are the only acute, inflammatory diseases, purely local in origin, of the synovial membrane. But a large number of joint-diseases are due to absorption into the blood of poisons, in all probability of different sorts of pus.[1] Other forms of joint-malady are merely local manifestations of diatheses—rheumatism and gout—while one synovitis of subacute form is ascribable to an acquired taint, viz., the syphilitic.

These various forms must be studied, and we will take them in order, as above. Diseases which produce synovitis by absorption are very many, and may be arranged as those: (1) Following or accompanying wounds or childbirth; (2) following or accompanying gonorrhœa or the use of bougies, etc.; (3) following or accompanying pregnancy and certain disturbances of the menstrual function; and (4) following or accompanying the exanthemata and dysentery. The first of these divisions includes all those forms of pyæmia in which articular manifestations occur. The etiology and symptoms of pyæmia have been already given in this work,[2] and it will be gathered from the article on that subject, that the disease is very variable, and may occur under widely different circumstances; and so also we find variety in the modes of local manifestation, variety in the places where secondary deposits take place, and variety in the appearance of the affected joints and of the tissues immediately next the deposit. As a very general rule, several joints are affected, some only in a transient manner for thirty-six or forty-eight hours, others more persistently. When after death the parts are examined, it is found that the chief deposition has occurred either within the joint cavity or in the surrounding parts—especially in the tendinous sheaths[1]—rarely simultaneously in both places. If the joint cavity be the seat of deposition, the periarticular tissues and neighboring sheaths are more wet than usual with a serum that is generally a little turbid. When the secondary deposit is outside the joint, there is hardly more than the ordinary amount of synovia within that cavity, nor have I, as a rule, found it changed in quality; sometimes it is inspissated like the fluid of ganglia, but quite bright; sometimes it is rather large in amount, rarely muddy.

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[1] In some of these cases the pus is putrid or putrescent, in others it contains a virus due to certain fevers or exanthemata.

[2] Vol. I. p. 203 *et seq.*

The pus of the secondary abscess is often in its macroscopic characters quite normal; it may, however, be already separated into turbid serum and sodden flocculi, or it may be thick and of a brownish color, sometimes uniformly, sometimes in streaks or blotches. The microscope shows that even in the apparently "laudable" samples the corpuscles are irregular and broken down, and this is still more the case in the abnormal varieties. Very frequently the fluid has a faint sweet smell, a slight exaggeration of the pyæmic breath-odor; not unfrequently the taint is more decided, recalling the odor of putrefaction—or is exactly that detected during life in the patient's wound or discharges.

Occasionally, the tissues which are the seat of the deposit are a little pinker than usual, especially if the disease be of some standing. The pink coloration is seen in little scattered spots; these are usually, and this especially refers to the synovial linings of joints or sheaths, a little yellow, and are here and there softer and more fragile than in the normal state, their endothelial lining being sodden and loose. In the great majority of cases, and until the pus has been for some days in the part, there is no sign of inflammation, or, more strictly speaking, of inflammatory phenomena, such as hyperæmia, thickening, etc.

From this it must be concluded that the pus is not produced by inflammation of the tissues among which it is deposited; the contrary sequence of events may, however, occur, viz., that the pus deposit, after a time, provokes inflammation in its immediate neighborhood.[2] Nor must we, on the other hand, suppose that the materies morbi is taken up bodily from one part and deposited in that form in another; it appears rather that by certain matters (living or chemical contagium) received into the blood, that fluid is so changed that it consists chiefly of altered leucocytes and a not perfectly healthy serum; that these leucocytes have a great tendency to aggregate, hence to fall to the sides of the vessel, therefore to emigrate; that in this single act the process resembles one act of inflammation, but that the other factors of that state, viz., the condition of the blood, that of the vascular walls, and that of the tissues, are either absent or entirely different.

SYMPTOMS OF SYNOVITIS BY ABSORPTION.—The general symptoms of the pyæmic state do not concern us here; it need only be said that after a certain duration of characteristic pyrexia and exhaustion, the patient complains of pain in one or more joints, or may simply, without complaint, cease to move a certain limb. On examination, the joint or joints will be found swollen, and, save in exceptional cases, other articulations will in a few days be similarly affected. The swelling is not like that of simple synovitis. Even when the joint-cavity is manifestly full of fluid, considerable periarticular effusion, sometimes evidently situated in tendinous sheaths, masks the shape of that membrane in distension. The skin is in nearly all cases white. If redness be present at all, it is of a pink quality, in lines, and in the site of lymphatics. A network of large veins is commonly very distinct, and this appearance is usually combined with œdema of the limb below. The temperature of the body is in this disease very high, but I have never been able to find any local elevation about an affected joint.

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[1] This is more especially to be observed in such joints as the wrist or ankle, which are crossed by many tendons in synovial-lined sheaths.

[2] I would call attention to the fact that, after death from severe but not too rapid pyæmia, the vessels of transparent tissues, for instance, those of certain parts of the peritoneum, of the lung-surface just beneath the pleura, and more especially of the pia mater, will be found in many areas, and through certain lengths of their course, to contain a yellowish fluid like very thin pus, amid which a central streak or dots of red will be found.

Metastasis from joint to joint is in the early stages common; in the latter—that is, when the local disease has lasted six days—it is rare. In certain of the more chronic forms of blood-poisoning, and especially in such as will now come under consideration, the patient complains of pain in several joints, as the shoulders, sterno-clavicular joints, wrists, knees, etc. Examination reveals no swelling, but there is usually some tenderness. After a few days, most of these pains disappear, and localize themselves in one or two articulations, which then assume the characteristic appearances. It is these vague, multiple joint-pains which cause some of these maladies to be so often mistaken for rheumatism.

If we keep before our minds a case of acute pyæmia from wound or from parturition, there would seem no possibility of confounding the disease with acute rheumatism; but, as before said, these are not the only forms of blood-poisoning with which we have to do; indeed, one of the diseases ascribable to this cause has, since the appearance of my writings on this subject, almost ceased to be called by its former name of "gonorrhœal rheumatism." I would name it instead, "urethral synovitis." It very commonly follows upon long-standing, or inveterate, or neglected gonorrhœas, and especially when the inflammation has passed far back; but it is occasionally produced by the use of bougies, etc. It usually begins with a rigor, and a rise of temperature up to 100 or 102° F., very rarely higher. After this, the patient, feeling very ill and depressed, complains of pains in several joints, among which is nearly always the knee. Ultimately one, or at most two joints remain affected. Sometimes a rather mild but obstinate conjunctivitis, rarely iritis, is also present.

After from five to nine days, the most severe stage of the disease subsides, and the temperature is rarely above 100° F.; but the joint, though but slightly painful while at rest, is very tender on pressure, and cannot brook any movement. This subacute stage is exceedingly obstinate, and at any time while the gonorrhœa lasts, even though it be a mere gleet, relapse may occur. If the patient, too, after being cured, contract a fresh gonorrhœa, he will, though years may have intervened, be almost certain to have recurrence of the articular disease.[1]

The existence of joint-affections connected with the female genital system was unsuspected by surgeons until a comparatively recent date, because they were always taken for rheumatism; nevertheless, there is no doubt but that such exist; and since the publication of my work I have received many confirmatory communications from other observers. Some of these affections are connected with the pregnant or parturient state, others simply with disturbance of the menstrual function. The former we may describe as "ante-partum" and "post-partum." Occasionally there seems to be a link of connection between the two varieties. Ante-partum joint-affections occur mostly about the fourth month of pregnancy, and, judging from what I have seen, are most common in women who, when not pregnant, suffer from leucorrhœa. Rigors are often absent, but pyrexia is always present, together with malaise and inertia—in short, the prodromata of a feverish attack, together with vague pains in the back and limbs. The fever, after about a week, subsides; the pains gradually become less general, and fix themselves, after wandering in a vague and capricious manner, in one or perhaps in two joints. When arrived at the uniarticular stage, the knee or the hip is the favorite joint.

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[1] For examples, see Volkmann, Krankheiten der Bewegungsorgane; Pitha und Billroth, Handbuch der Chirurgie, Bd. ii. S. 505. See also my work on Diseases of Joints, 2d ed. p. 113.

In most cases this malady subsides in from ten to twenty days, and the patient is thought to have passed through a subacute attack of rheumatism. But sometimes abortion intervenes, after which the recovery is more slow, the movements of the joint being difficult to re-establish; in some cases complete anchylosis ensues. A rarer form is very severe, even fatal; if, after six or seven days from the first attack, the fever does not decline, but, after irregular rigors, increases, the symptoms assume rather the form of traumatic pyæmia, and the affected joints become more swollen, fluctuate, and are evidently filled with pus. If in this typhoid state abortion takes place, death rapidly supervenes.

A similar but milder form occurring between the middle of the third and the sixth week after childbirth, is very unusual, unless it have been preceded by ante-partum synovitis. It usually begins in the shoulders, elbows, and wrists, yet generally migrates to the lower extremity. The pyrexia is not great, and the local affections are chiefly periarticular. The patient usually recovers without permanent damage to any joint.[1]

The synovitis connected with irregularity or with accidental suppression of the catamenia is sometimes a mild, at other times a severe disease. I have known it to occur in matrons who had borne many children, and in the unmarried. It is most apt to attack women of lax fibre, who suffer from leucorrhœa, and who during a menstrual period are exposed to cold, producing suppression of the flow. A feverish attack follows, often preceded by rigors, and accompanied by pains in several joints, which are usually ascribed to rheumatism, and which, after a few days, concentrate themselves in one joint (rarely in two), most generally the knee or hip.[2] The characteristic local conditions of all this class of cases are well marked, viz., that the swelling is largely periarticular, and that after the first few days pain, while the joint is at rest, is almost absent, but is very severe on contact or movement.

We now turn to another set of similar, but not identical, joint-affections, which arise during the course or after the subsidence of certain fevers—viz., enteric fever, smallpox, scarlatina, diphtheria, measles, and mumps—and also of dysentery. This class of joint-diseases deserves a closer study than has yet been accorded it, but a difficulty lies in the apparent rarity of these affections, which almost precludes the possibility of any one practitioner seeing a sufficiently large number of cases. Yet it may well be that when attention is called to the subject, these conditions may be found more common than they are at present supposed to be. For instance, we often hear of a "rheumatism consecutive to scarlatina;" less often of one "consecutive to measles;" but a better appreciation of these multiple joint-pains, which have been thus likened to rheumatism, would insure a clearer insight into their nature, and a better starting-point for their study.

In the first place, I would point out that of most of these diseases, suppurations, broken surfaces, or ulceration, is an integral part; and that, therefore, there is a clear point of inter-relation between them and the possible absorption of morbid matters, while there is no evident connection between these maladies and subacute rheumatism. Moreover, the supposed "consecutive rheumatism" has never the slightest tendency to induce pericarditis or endocarditis.

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[1] In one out of the only four cases that I have seen, a false anchylosis of the elbow took place.

[2] In the two most severe cases that I have seen, the knee was attacked in one, the hip in the other; in both cases false anchylosis resulted.

The joint-disease of *typhoid fever* is peculiar, as having a marked tendency to attack the hip and to produce rapid dislocation. I have seen three cases of this kind, and my colleague, Mr. Bellamy, had another case under his care, in which suppuration of the left hip occurred during the course of typhoid fever. In the three cases which I saw, the dislocation occurred, in one, during an unknown period of the fever; in two, some time during the third week. In two cases the patients were very apathetic and comatose, and did not complain of pain; in one of them the dislocation was only discovered as the patient began to convalesce. In one of the three cases the patient suffered much at the hip during three days, when the pain almost suddenly ceased; probably this cessation was due to the dislocation, and consequent relief of tension. In none of the cases could the bone be replaced. There is occasionally, too, during typhoid fever, a multiple form of synovitis, of which I have seen but two examples. *Mumps* is, as is well known, subject to singular metastases—sometimes to the testicle, less usually to the brain, still less commonly to one or more joints; it rarely passes to more than two articulations, and more often is confined to one. When the two former changes of place occur, the parotid ceases, as a rule, to be inflamed; but the disease may leave the part secondarily attacked, and return to its first locality. When a joint or two joints become affected, the parotitis continues; nor does the joint-disease exhibit sudden shifting of place. It is characterized by rapid effusion into the synovial membrane, and by severe pain. I believe this condition to be brought about by impregnation of the blood with inflammatory products.

Exanthematous synovitis may be either a mild or a very severe affection; it is multarticular, and in its milder manifestations is so very like acute rheumatism as to be generally mistaken for that disease; in its severer forms it not only leads to local lesions, but comports itself like ordinary traumatic or puerperal pyæmia; *scarlatina* is that exanthem which is most often followed by these manifestations, especially in the more violent forms; *measles* that which leaves the most persistent, chronic sequelæ, after passing through the usual acute stage. I cannot see any generic difference between the milder and the severer form; the amount of poison absorbed, or the condition of the poison at the time, causes a difference in the amount of local and constitutional evil produced. There is also a peculiar joint-disease, consecutive to, rather than a cotemporary of, the exanthemata, more especially *scarlatina* and *diphtheria;* it is uniarticular, and attacks the larger, never, as far as I know, the smaller joints; it is marked by very rapid and considerable, but painless, effusion, and occasionally by dislocation; it attacks, in preference, the shoulder, hip, and elbow. Synovitis has been observed after *dysentery*, more especially after epidemic dysentery; the disease begins with the commencement of convalescence, never attacks any joint but the knee, and is marked by considerable effusion.[1] It is a rare disease. *Measles* is followed rather than accompanied by a later and a slower form of synovitis, extremely apt to become quite chronic, and to degenerate into the ordinary form of strumous synovitis. All who have had much experience in the maladies of childhood, must have noticed how frequently the commencement of scrofulous disease of the cervical glands, of the viscera, or of the joints, tallies in point of time with the convalescence from measles.

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[1] See Braun, Schmidt's Jahrbüch. Bd. xviii. S. 202; and Witowsky, Prager Vierteljahrsschr. 1847.

One point which I have left to the last, but which is of much importance pathologically and practically, is the singular fact that all these joint-affections which occur in connection with fevers, are in certain epidemics comparatively frequent, in others extremely rare. There is at present no clue to the interpretation of this peculiarity, nor will any be found until the conditions of bodily temperature, dates of eruption, periods of convalescence, atmospheric conditions, etc., in such epidemics, are carefully noted and compared. The knowledge of the fact cannot, however, be otherwise than useful to the practitioner who encounters one such event, in his interpretation of succeeding ones.

Treatment of Synovitis from Absorption.—Since the joint-affections of pyæmia, whether from wound or parturition, are but local accidents of a systemic condition, the topical management of the articulations can be merely ancillary to the general treatment of pyæmia. I am very far from considering that pyæmia is a hopeless condition, as if the patient had received an irremovable dose of some necessarily fatal poison. On the contrary, if the clinical histories and the temperature charts of a number of cases be studied, the opposite conclusion is almost inevitable. We find in the beginning a rigor, or succession of rigors, followed by a rise of temperature; after a certain number of hours the thermometer falls, then follows another rigor, and another period of pyrexia, and so on alternately. In cases in which the contagium is not very powerful, or in which the patient is of a strong constitution, the intervals between the fits of rigors are fairly prolonged, and the temperature becomes almost normal before each succeeding attack. Where the opposite conditions obtain, the rigors succeed each other very rapidly, and the thermometer never sinks much. In the worst cases, the initial shivering fit is followed by a pyrexia which never much abates, and if rigors recur, they are ill-developed or abortive. The first of these clinical conditions evidences an alternate absorption and elimination of a morbid material—a poisoning by reiterated doses; the second, a like series of events, but, the dose being either stronger or more rapidly absorbed, is not so fully excreted previous to the reception of a fresh instalment. In the third set of cases, the poisoning is more potent and continuous. Hence it is to be concluded that the system has great power of getting rid of the contagium, but that it may succumb to persistent poisoning, either continuous or remittent.

These considerations suggest two methods of treatment: (1) to aid the elimination or destruction of the poison already absorbed, and so to fortify the system that it may carry out these processes to a successful issue; (2) to annul or weaken the local source where the poison is formed and whence it is absorbed. These two must in most cases be combined. In puerperal pyæmia, the source of poisoning is some sepsis within the genital tract, and there is no doubt that, if either by plentiful aseptic irrigations, or by removal of putrefying placenta and clots, or more certainly by both means combined, the source of putrefactive poison can be destroyed, the patient who has not already absorbed too much, may be saved.[1]

A wound which has got into such a state as to set up systemic poisoning, must be treated on the same principles, the mechanism being modified to suit the situation of the poison. Thus, it should be opened up so as to expose all its depths and crevices as completely as possible, and these must all be thoroughly washed and purified with carbolic acid, boro-glyceride, or some other antiseptic. But since the tissues around the wound certainly contain, and will, if left uncared for, generate, fresh contagium, some means of annulling or minimizing this production must be used. I have found the best method to be by interstitial injection, using for this purpose a tubular needle, perforated not only at the end, but in several points at the sides; the collar of the needle either fits a syringe holding about an ounce, or by means of an India-rubber tube may be connected with a glass one of $\frac{1}{4}$ or $\frac{3}{8}$ inch diameter.[1] The needle is introduced into those parts where lividity is present, where veins are enlarged, or in the course of veins, and by predilection above the wound, and is moved somewhat while the fluid flows; from one to three fluidrachms of a 3-per-cent. solution of carbolic acid may be safely injected. While this treatment is being conducted, a portion of the urine from each micturition should be put aside to be examined before another injection is made; if the urine does not assume the inky appearance due to carbolic-acid poisoning, the dose may be repeated, and, when desirable, even increased.[2]

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[1] In my work on joint-diseases, a striking example of this mode of treatment is recorded; and Dr. Matthews Duncan has published very similar cases.

On each occasion, care must be taken not to let all the fluid used accumulate at any one point, but to spread it over a certain district; and on each repetition of the injection, a fresh part must be chosen until the vicinity of the wound is exhausted, and then the series may recommence.

In the mean time, the temperature must be reduced by the administration of suitable remedies. If the skin be dry and hot, an effervescent solution of citrate of ammonium is very valuable.[3] It may be given every three or four hours for one or two days and nights, or until the skin becomes moist. Afterwards, or even at the beginning, if the surface is not at the commencement markedly dry, we may administer large doses of quinine. In giving the drug for this purpose, it is better not to temporize, in view of the grave condition with which we have to deal; a little headache or temporary deafness is unimportant, and I would therefore recommend 20 grs. given in one dose, to be followed by a like amount in two hours, or if the case be severe in one hour; and then, if the temperature fall, after an equal interval by 10 or 5 grs., according to the effect produced; at the same time, a stimulant—brandy, champagne (especially if there be sickness), or sherry—may be properly administered. If no parenchymatous injections of carbolic acid be used, perhaps even when their employment produces no sign of poisoning, another drug may be administered by the mouth—and I believe myself to have seen it productive of benefit—namely, the sulpho-carbolate of sodium, in scruple doses. There is no doubt, as shown by the odor of the breath and the occasional discoloration of the urine, that this drug becomes absorbed into the blood, and must in so far render that fluid unfavorable to the life of septic fungi.

In the general treatment of less acute forms of this malady, such as urethral or catamenial synovitis, less drastic remedies are necessary. I may be permitted to say, that the analogies with the rigors occasionally following catheterization, are not to be ignored. Those shiverings are successfully treated in one of two ways: We may either immediately give one or two large doses of quinine; or we may administer a glass of very hot spirit and water, cover the patient warmly with blankets, and cause him freely to perspire. It is probable that were a surgeon called, upon the first manifestation of the other forms above named, one of these methods might cause the attack to abort; at all events, my observations go to prove that considerable sweating will both shorten exanthematous synovitis and relieve the pain.

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[1] The length of a column of fluid, an ounce in quantity, contained in such a tube, insures considerable pressure on the liquid in the needle.

[2] Since introducing boro-glyceride as a surgical dressing (see Lancet, May 13, and Brit. Med. Journal, Aug. 26, 1882), I have had no opportunity of testing its value in pyæmia, but as it is a powerful aseptic it would probably be followed by good results. As it is not a poison, more entire and wide-spread saturation of the tissues would be possible, than with carbolic acid; but powerful as boro-glyceride is in preventing sepsis, it is not, I think, as potent as carbolic acid in counteracting a putrefactive action already set up.

[3] Made by mixing solutions of 25 grains of carbonate of ammonium in a fluidounce of water, and 20 grains of citric acid also in a fluidounce of water.

Purgation, in all these cases, should only be employed when the alvine condition necessitates its use, or when the excretions are particularly foul. It is true that a certain amount of elimination may be effected, but we must remember that absorption will at the same time be stimulated.

Thus much for the general management; as for the local treatment, it must, in severe cases and while the danger is very imminent, be limited almost entirely to the use of some light support; such patients lie sometimes apathetic, and perfectly still, but at other times there is much jactitation. Under these circumstances, to apply any strict restraint would be imprudent; to maintain it, usually impossible. The arm may, however, be bandaged to the side, a pad or cushion being interposed, when the shoulder is affected; when the hip is attacked, the use of weight-extension is the best treatment, since, while restraining, it yet yields to movement. For like reasons, in disease of elbow or wrist, or knee or ankle, the limb should be placed in some light splint and sling. Besides these mechanical means, it may be desirable, when the genital passages or the neighborhood of the wound have been cleansed by irrigation or injection, to apply the latter mode of treatment to the periarticular tissues also.

But, when the urgent pyrexia is past, the joint-affections often become very lingering; indeed, some of them, as, for instance, the urethral and catamenial varieties, usually assume that character from the first, while other forms often exhibit a tendency to run into suppuration, or to terminate in rapid anchylosis; this is especially the case after scarlatina. Hence, in all these cases retentive apparatus is desirable. At first, and while any heat is present, or while the points of special tenderness are impatient of pressure, those appliances which keep the joint at complete rest should be used; afterwards, and particularly in those maladies which most tend to anchylosis, the forms of splint which prevent pressure, while permitting a certain amount of movement, are preferable. In protracted cases, where a certain low form of fever continues for a lengthened period—when the bodily powers have been so weakened that we cannot much move the limb, or the patient, without danger—one of those forms of splint which facilitate the retention of the limb in various positions should be employed. In such an apparatus, the limb can be kept in perfect quietude at an angle which is changed every twenty-four or forty-eight hours, so as to prevent true anchylosis, and so as to cause the bands of a false anchylosis to be as lax as possible.

STRUMOUS SYNOVITIS.

Struma is a state of the body which is usually inherited; it is not a disease, but a condition which renders many of the tissues (lymphatic, connective, epithelial and endothelial) very prone to respond to slight sources of irritation, by prolonged inflammations tending to suppuration and caseation. A child who is strumous, although bearing certain characteristics that mark the constitution, may for years, perhaps altogether, escape disease, but if some excitation, traumatic or otherwise, arises, the resultant malady will present the diathetic type. Now the marks above referred to are produced by certain characteristics in the nutrition and growth of the connective, lymphatic, endothelial, and epithelial tissues. They are of two varieties:

the one, in which a considerable tendency to growth is combined with incompleteness or at least tardiness in completing the process; the other, in which the finish of the modelling is perfect, even exquisite, but in which the nutrition or assimilation by the tissues is insufficient. The former of these types is marked by a want of definition about the making of the features; we might say, if we were speaking of a sculptor's work, that a rough lump-sketch had been blocked out, but that the outlines had been left blurred, and that the modelling was unfinished. Thus the head is large and uneven, big behind; the ears are large and stand out widely, their folds and edges being thick and badly marked; the undecided, thick, under lip is apt to droop, and both it and the upper one to crack; the alæ of the nose look swollen and have no distinct edging, nor do they come off from the face at a well-defined place, unless marked by redness round about. The eyelids also, often edged with red, and fringed with short, thick lashes that stand out in different directions and are apt to mat together, have the same lack of clear and distinct modelling; add to this a dull, coarse hair, gravel-colored or lustreless black, and we have the strongly drawn type of that struma which tends to the scrofulous, the glandular-swelling variety. The characteristics of the other kind are much more pleasing, indeed often exquisitely beautiful: the thin skin, almost translucent in its delicacy, either of the milk-and-rose or of the soft-brunette complexion, covers features of the finest form and most refined modelling; the long eyelashes fringe their lids marked with a delicate tracery of wandering veins; the eyebrows are softly pencilled; the forehead is placid and smooth, with ash-gray tones in the half shadows; the long hair is delicate, fine and silken in texture; and the lips are red and finely cut. There is no particular complexion for this form; the hair varies from brown, through auburn, to very fair.[1] Often a fine but long down grows on parts not usually hairy, especially at the edges of the usual capillary growth—for instance, low and far forward on the temples and sides of the forehead. This type tends little to scrofulosis, but rather to tuberculosis.

Both these types of personal formation are the result of certain peculiarities of nutrition, affecting the areolar and other connective tissues; and since inflammation is but a modification of nutritive acts, it is evident that if nutrition be peculiar its modification will also be of a peculiar type. We find therefore that inflammations occurring in strumous persons—or, if we like to call them so, "strumous inflammations"—are marked by certain special features, viz., a tendency to fall into a very chronic form, and for the inflammatory products to remain during lengthened periods embryonic (granulation-tissue), and then either to caseate or to suppurate with much fatty degeneration. Indeed, according to Billroth,[2] "we may assume a scrofulous diathesis for those cases in which a slight and transient irritation of some part of the body sets up a chronic inflammatory process, which not only outlasts the irritation, but spreads or continues independently of it, and which usually results in suppuration or caseation, and rarely assumes the form of pure hyperplasia."

In the British Islands, and more especially in the large towns, struma is very prevalent; hence we have to do, in both hospital and private practice, with a great number of inflammations which have the characteristics given by Billroth very strongly marked; among these is a class of very chronic and very persistent joint-diseases, having but little tendency to get well, but apt rather to run on to destructive processes. The history of such cases may be conveniently described as passing through three stages.

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[1] The combination of very dark hair with blue eyes is significant.

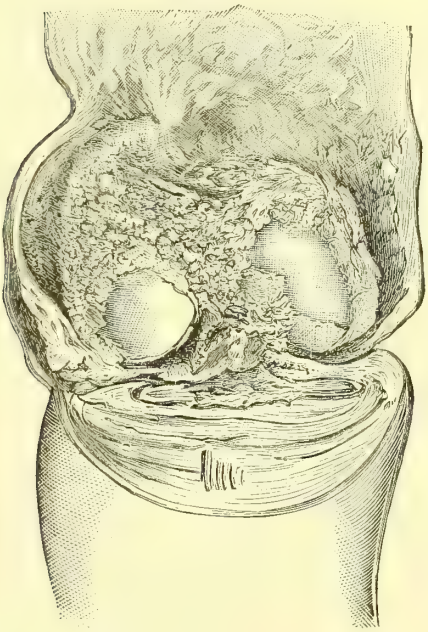
[2] Scrophulosis und Tuberkulosis; Pitha und Billroth, Handbuch der Chirurgie, Bd. i. Abth. 2, Heft 1, S. 311.

First Stage.—A child, generally under eight years, who may or may not have had an attack of measles[1] or scarlatina, or who may have suffered from enlarged cervical glands while cutting the back teeth, or who may hitherto have been perfectly healthy, is observed sometimes, without any sign of pain, to have a swollen joint. In some cases this is preceded by a slight injury, in others the evidence of traumatism is conjectural, and again in others the absence of any violence is distinctly affirmed; often, and these cases are in the end the worst, there is no evidence of pain.

The enlargement slowly increases, and soon the child limps, if the lower limb be the seat of disease. When examined, the swelling is seen to be of a very shapeless, indefinite character—rounded, but not marked by the ligaments, etc., as in acute synovitis; its consistence is semi-elastic, and in this stage equally resistant throughout, concealing both to sight and touch the form and markings of the bones and other anatomical points. The joint is easily movable within certain restricted limits, and the motion, unless these limits be overstepped, is painless, as is also moderate pressure. The color of the skin up to this point is either unaffected, or it is rather white.

The opportunity of examining joints, even in this very early stage, sometimes fortuitously occurs; we find then that the cavity contains a slight excess of fluid, which usually is turbid from the admixture of many cells, some of which are like leucocytes, but most of which are derived from the endothelial lining of the synovial membrane. The inner surface of that structure is no longer smooth and polished, but is studded with little rounded or pyramidal elevations, and presents, not the branched and dendritic growths of suppurative synovitis, but a different form of fringe, hypertrophied into thin, vascular membranes, which encroach upon and overlie the cartilages. They are at first quite fine and delicate, digitated or foliaceous, and fenestrated here and there, where in their luxuriant growth two or more of the digits have coalesced at their extremities, leaving an unoccupied space between. Very soon these pannus-like formations increase in thickness, become coarser, inflame, and granulate like the other soft parts of the joint-structure, and at last form an inflammatory tissue. The cut edge of the synovial and perisynovial tissues presents (Fig. 636) a jelly-like appearance, and is continuous with the round and pyramidal elevations above mentioned. The color of this material is light pink or yellow, with the suspicion of a green tinge in the shadows; through it run long, wavy, hardly branching vessels, and thin white lines of unaltered or scarcely altered fibrous tissue. This gelatinous material encroaches on the joint-cavity, and extends toward the skin to a degree varying with the duration of the disease.

Fig. 636.



Strumous synovitis; granulation tissue lying on the cartilage. (From a specimen in the Museum of the Royal College of Surgeons.)

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[1] The first symptoms of strumous disease are frequently dated from a protracted convalescence after measles.

A shred or fine section of this material shows it to be composed of a mass of cells, round and spindle-shaped, together with bare nuclei, the whole held together by ground-substance, granulated or delicately fibrillated, and of very soft consistence.[1] The area pervaded by this material is not equally thick in all parts; in one spot it may hardly encroach beyond the immediate neighborhood of the cavity, in another it may be much thicker, while in a third place it may send out a prolongation extending a considerable distance. Wherever it exists, it invades any intervening structures; it grows in the interstices of ligaments, and gradually separates or transforms their fibres; that is, the cells of the areolar tissue which pervades those structures, forms by proliferation this sort of material.

This substance is granulation-tissue, exactly like that which forms the floor of ulcers, and produced in a precisely similar manner; the act of granulation is not confined to strumous joint-disease, it occurs also in ordinary chronic synovitis, such, for instance, as is left after an acute attack; and though in the strumous disease the granulation-tissue is unusually soft, the action itself is not peculiar to that malady; it is the after-behavior of the granulation-tissue which individualizes the disease. Thus, in the chronic stage of an acute synovitis, the granulations develop rapidly into a fibrous form of cicatricial tissue, and this tendency is, as we shall see, still more strongly marked in chronic rheumatic synovitis. But in the malady which we are now considering, the new tissue has little or no tendency to cicatrization or fibrillation; it remains, or at least tends to remain, for an indefinite time, the same unformed or embryonic material; and, then, without further organization, is apt to undergo either fatty or purulent degeneration.[2]

There remains yet another degenerative process which must be noticed—the *tuberculous*. For very many years past, the possibility or probability that the extreme obstinacy of strumous synovitis, such as just described, might be due to tuberculosis of the synovial membrane, has been constantly borne in mind; I myself have not only been prepared for the reception of evidence to prove the fact, but have also been aware that old and indolent granulations—tuberculoid nodules—consisting in great part of giant-cells, could be found in these cases. Within the last two years, however, the subject has reached another phase.

In 1880, Dr. Max Schüller published his well-known account[3] of experiments on a number of animals which he had rendered diseased by the injection of tuberculous matter, and in which he had at the same time, or at least during the same day, as a rule, injured the right knee-joint. With these experiments, and with the inferences drawn therefrom, is intimately mixed up the doctrine of a special living organism as the cause and origin of tubercle. With regard to this work and this doctrine, I can only say, while acknowledging fully and freely the great industry and patience involved in Dr. Schüller's labors, that they require much confirmation. I cannot consider them in any way conclusive, concerning what for us just now is the important point, the origin of strumous synovitis in tuberculosis of the synovial membrane. This is certainly not the occasion, nor have I here the space, to enter into a detailed criticism of Dr. Schüller's work; but I must point out that the history which I have given of strumous synovitis, is that of a very slow malady, commencing in children either a little weakened and depressed, or apparently in fairly good health, and who have either received a slight injury to the joint, or none at all. The right knees of Dr. Schüller's rabbits and dogs, after they had received into their lungs a considerable quantity of tuberculous matter, were injured ("contundirt"). "The leg did not undergo dislocation or torsion: partly because, although the ligaments were torn, very little or no blood was effused into the joint or the tissues; partly because the bones at the epiphyseal lines were fractured; that is to say, the epiphyses of both femur and tibia were torn away."[1]

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[1] The cells are evidently produced almost entirely by the proliferation of the connective-tissue cells, emigration-corpuscles playing but a very small part in their formation.

[2] The anatomical condition above described is that which Sir B. Brodie called "A Morbid Change of Structure of the Synovial Membrane." The disease is what Wiseman called "White Swelling," a term which afterwards was extended to many forms of joint-disease. Bonnet (Maladies des Articulations) and Richet (Maladies des Articulations) term it "fongueuse." Volkmann (loc. cit.) names the disease "Fungöse Gelenkentzündung." Hueter (Klinik der Gelenkkranheiten, Bd. i. S. 77) would make distinctions among all those chronic forms of synovitis in which considerable thickening or hyperplasia takes place, naming them respectively *synovitis hyperplastica*, with the adjuncts *lævis* or *pannosa*, *granulosa* or *fungosa*, *tuberosa* or *papillaris*; but these somewhat grandiose names indicate no real pathological differences; indeed, he confesses "that in the same joint these different forms of hyperplastic inflammation coexist." They are, indeed, mere variations, according to the degree and stage of the disease, according as the granulations tend more or less to advanced development.

[3] Experimentelle und histologische Untersuchungen über die Entstehen und Ursachen der skrophulösen und tuberkulösen Gelenkleiden, u. s. w.

After injecting various forms of tubercular tissue into the animals' lungs, and damaging their right knee-joints in the way described, Dr. Schüller found in the inflammatory products about the injured knees, sometimes histological elements which he considered tuberculous, at other times such as he thought doubtful ("vielleicht als initiale Tuberkel"), at others, appearances not even colorably tuberculous.

Now it must be confessed that these animals (generally rabbits, which are prone to tubercular disease), artificially affected with acute tubercular intoxication, and at the same time with very severe traumatism of a joint, were in a state by no means analogous to that of a strumous child who has hereditary tendency to, or is actually ailing from, chronic tuberculosis, and who may have received slight or no articular injury.

Dr. Schüller describes, excellently and minutely, various conditions of low, fungoid granulations which affected the "contundirt" joints; but, of course, he could not find, in these infected and often almost moribund animals, the same forms of inflammation as in healthy creatures receiving a like injury; the process of inflammation in weakly systems tends to the production of fungous or pannus-like forms, quite independently of tubercle. And not merely must the ill state of health in these animals be taken into account, but also the fact that embolic clots are very apt to lodge in the synovial tissues, especially if injury have rendered them hyperæmic.

But let us shortly examine the results of injections and contusions in 24 animals. Of these, five were infected with phthisical expectoration; these all showed changes considered to be tubercular.[2] Six were infected with minute pieces of tubercular lung. Of these, one died on the fifth day, and one (a dog) was killed three and a half months subsequently; his internal organs "were extremely thickly beset with pearl-gray tubercles;" in the granulations of the injured joint were several white nodules, not as large as a pin's head, and in one place other signs ("perhaps giant cells") still less significant; the other four animals (rabbits), dying in from 15 to 34 days, showed spots on the synovial membrane which "may perhaps be regarded as initial tubercle." Six were infected with portions of tuberculous lymphatic glands; they died or were killed at various periods, from 12 days to 3 months, and though several succumbed to general tuberculosis, the utmost similarity that the joint-appearances bore to tubercle consisted in their presenting "masses of round, oval, and caudate (birnenform) cells ranged together, having the appearance of *heaps of epithelioid cells*" and "*colossal giant-cells.*"[1] Four were infected with lupus tissue; of these none showed anything more characteristic of tubercle in the synovial membrane than "quantities of round cells in the superficial layers of the synovial membrane." Lastly, three were injected with tuberculous (?) synovial membrane; the joints of these, again, showed nothing characteristic of tubercle. Therefore, of the 24 injured and infected animals, we find that only those infected by sputum showed any clear marks of tubercle in the joint structures, save one dog infected with phthisical lung tissue.[2] Actual, pulpefied tubercle injected into the lung appears to have had little or no effect in producing joint-tubercles, even though the animal died of tubercular infiltration of the lungs, liver, spleen, and kidneys.[3] It is, of course, with so careful an experimenter as Dr. Schüller, not to be doubted that the material injected was what he intended, and that it was non-putrescent. But can this last condition—non-putrescence—ever be insured with sputum? The expectorations of phthisis contain, no doubt, a certain amount of tubercular matter. The same must be said of such lung-tissue, lymphatic glands, etc., as were used in these experiments; but the experimentalist assures us that these latter were as fresh as possible (thünlichst frisch). On the other hand, the shreds of lung-tissue and the detritus of tubercle that form part of the expectoration of phthisis, are much changed, even before they become detached; then, while enveloped in pus or muco-pus, they and the secretion are long exposed to currents of not very pure air, by which they are moved up and down the bronchi and trachea, until finally ejected in a state particularly likely to produce, in the blood of another animal, those dyscrasiæ of which embolic and other infarcts of synovial membranes form a notable and integral part. It appears to me very significant, that these particular injections should have been followed by so much more marked effects than others of equally or more tuberculous substances. Neither are the subsequent experiments, carried out with fluids cultivated from tuberculous tissues, in any way more convincing; indeed, in them lies another source of possible fallacy. They show that a certain cultivated organic poison, derived from tuberculous tissues, produced in the lungs what was very possibly tuberculosis, but at the joints, again, the "perhaps initial tubercle," and certain spots of which it could only be said that "they might be considered as tuberculous formations."[4]

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[1] Op. cit., S. 19.

[2] I will not here compare my histological experience with that of so practised a microscopist as Dr. Schüller, but I confess to feeling by no means sure that many of the nodular cell-accumulations described in his work were tubercle. The anatomical characters of that material are not as yet determined; certainly, giant cells cannot be accepted as conclusively characteristic. They arise in old granulations of almost any unhealed wound, where vascularity happens to be deficient, and by the same law in the persistent granulation-tissue of strumous joint or bone inflammation. I certainly could not, for instance, accept some specimens shown at the Pathological Society, as undoubtedly examples of tubercle. (Path. Soc. Trans., vol. xxxii. p. 174.)

How far Dr. Schüller's investigations may go to prove the existence of a living organism as the generator of tubercle, does not concern us here;[5] our task is purely surgical, and in this place only concerns the joints. With regard to these, the experiments appear to show that, even while internal organs are deeply infected with acute and subacute artificial tuberculosis, the synovial membranes, even though severely injured, will resist the infection to such a degree that, as a rule, only doubtful or "initial" signs of tuberculous action can be detected by either naked-eye or microscopic research.

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[1] The italics are Dr. Schüller's.

[2] Did space permit, it would be easy to show—this creature's internal organs being stuffed with tubercle for three months—that the inflamed synovial membrane could hardly escape.

[3] One is a little struck to find that granulations from so-called tubercular joints had no effect.

[4] Op. cit., S. 64.

[5] It is curious that Schüller should describe and picture this organism as a micrococcus, oval or pear-shaped, and that Koch should call it a bacillus.

Moreover, it is a very instructive outcome of these experiments, that in no single instance was a joint, that had not been artificially injured, affected with inflammation. If a tuberculous condition of body could render the person or animal peculiarly liable to fungating forms of synovitis, many of those animals, which succumbed or were killed, after a certain number of weeks or months, with lungs and other viscera stuffed or studded with tubercle, would, we should suppose, have shown some marks of joint-affection. But such a condition, save merely as regarded the direct result of injury, was uniformly absent. We know that struma and tubercle are in some way (though we know not how) closely allied; we see, again and again, children with strumous joint-maladies dying of phthisis, or of tubercular-meningitis, while still the articular disease is nascent, and certainly non-tubercular. In this fact, again, we have therefore another evidence how little prone to tuberculosis are the synovial membranes. I confess to have believed that the inflammatory granulation-tissue of strumous synovitis was very apt to be affected by tubercle; but the difficulty which Dr. Schüller encountered in producing that neoplasm in "contundirt" joints of tuberculized animals, seems to render a re-examination of the subject desirable. But although the healthy synovial membrane, and perhaps the inflammatory tissue generated from it, appear to resist the invasion of tubercle, the latter, especially when it becomes old and fungoid, yields in certain spots to other forms of degeneration. The suppurative and fatty are common; the caseous (without passing through previous phases) not very uncommon; and also not very unusual is another, the pathological place of which is doubtful, in which one sees, in certain parts of the jelly-like granulation-tissue, little spots, rather dry and dull, looking almost as if grains of fine powder had fallen into it. So small are these that, were there but one or two, they would be imperceptible, or would, at all events, escape notice; but, as they are many, they give a peculiar, almost dusty, look to the specimen. Examined with a microscope of sufficient power, these spots show a closer packing of the cells, which may be round, or more often seem by pressure to have been shaped into a variety of epithelial-like forms. They generally lie so as to give the impression of a circular or ovoid arrangement, and in the centre of this circle are frequently one or two giant-cells; indeed, it appears to me that it is the growth of these giant-cells which, compressing those around them, causes the closer agmination, and the appearance of circular arrangement above described. That pressure has some share in the matter, may be seen by the fact that, when the section passes just over or through one or two of these spots, they cause a little projection of pin-point size, or sometimes larger. Whether or no these little spots be tubercle, must be decided by some future histologist. If they are so interpreted, they are merely the tubercle of inflammatory products; even those found in the injured joints of Dr. Schüller's animals belong to that category; and I suppose it has, for many years, been known that inflammatory products, when sufficiently persistent, are apt, in strumous individuals, to become tuberculous. But that is not the question—it does not even touch the only question of real interest and importance—which is, Does tubercle ever become deposited in a previously healthy synovial membrane,[1] and give rise to a typical inflammation? At present we have no evidence that this ever occurs; and Dr. Schüller's book goes very far to prove its non-occurrence, since even inflamed synovial membranes were with difficulty infected; and since, in the highly tuberculized animals which were the subjects of his experiments, there was not found a single spot of tubercle in any one uninjured ("nicht contundirt") joint.

[1] Cancellous bone-tissue stands in the same conditions

We must now leave this digression, and continue to trace the course of diseased action in strumous synovitis. We left the joint at the stage of heaped-up granulation-elements, having little or no tendency to form tissue; we have studied these only as becoming developed in the synovial and other soft parts, and have not as yet touched on the invasion of other articular constituents. The next two steps, if disease still persists, are invasion of the cartilage and bone, and degeneration with suppuration of the granulation-tissue; but it is not an unavoidable necessity that the malady must continue—must go on to take those two steps—the progress may be arrested at the point now reached. The embryonic tissue assumes further developmental action, and gradually becomes converted into fibrous tissue, while doubtless at the same time many of the cells and bare nuclei simply melt away and are absorbed. The process is exactly the same as the filling up and cicatrization of an ulcer or open wound, healing by granulation; the result is similar healing by means of cicatricial tissue, which in this locality is called thickening. It commences with cessation of the ordinary process of inflammation, namely, proliferation of cells; then those cells already formed undergo the necessary fibrous transformations elsewhere described. There is therefore a period, an interregnum after the cessation of inflammatory action and before the commencement of that which is reparative, during which little or nothing is going on; a period which, except in bad cases marked by decided cachexia, lasts, I believe, a considerable time.

It must not, however, be supposed that this cessation of inflammation is always so early—that is, previous to the invasion of cartilage and bone—nor indeed to a certain amount of degeneration and suppuration.[1] Neither must it be assumed that after the interregnum repair always sets in. On the contrary, the malady may then enter on its next stages. These, viz., degeneration of granulation-tissue and invasion of the harder parts, have no interrelationship either of time or causation. I have often examined joints the cavity of which has been all but obliterated, and the structures around which, even to the skin, have been occupied by unaltered granulation-tissue; and also other joints in which such tissue has greatly degenerated, while the harder structures have been sound; and yet again, in other cases, I have found that while much less disease of the soft parts could be detected, the cartilages and bones have been in great measure destroyed. Nevertheless, although the period when the harder parts participate in the morbid change is very variable, I propose, because that participation is so important a factor of the whole disease, to take this event as the line of division between its first and second stages.

Second Stage.—We have seen (p. 281) that the acute inflammation of a suppurating joint easily and rapidly spreads from one structure to another, and indeed all violent inflammations have a tendency to invade neighboring parts. But it is at first a little difficult to perceive how so quiet, so slow an act as strumous synovitis should be so all-pervading, how or why that process of cell proliferation should spread from the perisynovial tissue to others so unlike it as bone and cartilage. The solution is to be found in the histology of articulations. When at a certain very early stage of fœtal life, the limb buds first appear, no joints exist—the cartilage which is to form the limb bones lies undivided in its periosteum; soon, at certain places, transverse rifts appear, which, spreading outward from the centre, divide that cartilage into segments. The fissure does not extend straight and simply across the whole thickness of the cartilage, but near the edge bifurcates or becomes double, so that a ring of that structure is separated from the rest except at its upper and lower edges, where it is still continuous with the primordial cartilage. This ring, by a series of curious fibrillar changes, becomes afterwards the synovial membrane—which therefore is, and remains throughout life, in structural continuity both with the bone and with the cartilage of incrustation. Articular cartilage is but an unossified portion of the primordial cartilage; synovial membrane is also a part of the same structure converted into a tubular membrane; the fibrous joint-capsule is a metamorphosed ring of the original perichondrium. Thus a synovitis spreads by direct continuity of structure both to the cartilage and to the bone.

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[1] These later acts of healing are again referred to on page 307.

The disease of cartilage which arises during the course of a synovitis is likewise inflammatory.[1] In the section on Diseases of Cartilages, the histology of *chondritis* will be more fully described. Here it may be briefly said that the cells, like those of other connective tissues, proliferate; the corpuscles, therefore, at first enlarge, and then are ruptured; leucocytes also doubtless penetrate the mass. In consequence of this cell-action, the hyaline structure is broken up into fibres, some of which are subsequently absorbed or used up by the growing cells, while others become detached, and, falling into the joint-cavity, mingle with the tissue-detritus and the fluids. Many of the fibres, however, remain, and give a velvety texture to the floor and edges of the ulcer.

Wherever the inflammation has spread directly from the synovial membrane to the cartilage, the actions above described commence at or near the surface, and may be either very chronic or much more rapid. In the former case, the change is first marked by the appearance of a white or yellowish, opaque spot, generally protruding a little beyond the rest of the surface; this is found on section to be conical, the base at the surface, the apex at a depth varying according to the age and stage of the ulcer, until the point reaches to, or is truncated by, the bone. In and a little beyond the limit of this spot, the enlarged corpuscles, ruptured near the surface, and the fibrillated, hyaline structure, are very evident. In the quicker form of ulceration, these changes, though they probably occur, are hardly to be traced. When completed, the former kind of ulcer has a coarse, velvety appearance; the latter has a clean-cut though often very irregular edge. Every excess of action must be accompanied by increased nutrition, and to support the superabundant cell growth there must be an augmented flow of blood. The hyperæmia of chondritis may be seen by making a longitudinal section of the cancellar bone-tissue which immediately underlies the articular lamella. The red spot or blotch exactly opposite the ulcer of cartilage is a very decisive and well-marked appearance.

But when this hyperæmia has lasted some time, it produces certain local effects; the cancellar lining membrane assumes the same proliferating action, and the cancellar plates begin to inflame, the thin parietes rapidly softening and breaking down; the articular lamella disintegrates, so that now the ulcer of the cartilage leads directly down into a granulating cavity in the bone; or, to put the same subject in other words, the granulations springing from an inflammatory cavity in the bone pass through the ulcerated opening in the cartilage, and sprout into the joint, where they mingle with those granulations that spring from the synovial membrane.

Yet a different mode whereby cartilage becomes detached (not ulcerated) must be noticed: the cancellar hyperæmia produced originally at one or two spots by the cartilage ulceration, sometimes spreads laterally beneath the articular lamella, and the resulting osteitis is much more extensive than the original chondritis; the cancellar plates and articular lamella consequently give way for a considerable distance beneath cartilage which is still in a sound, or almost sound, condition. That piece of cartilage therefore, being now detached, lies floating, as it were, between synovial and bone granulations, having still adherent to its deep surface a sabulous matter composed of the detritus of the articular lamella.

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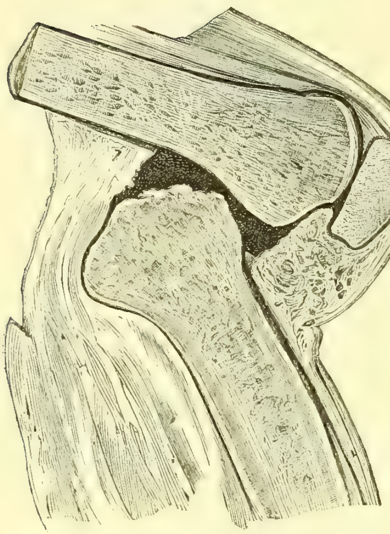
[1] It was considered, previous to 1860, that the cartilages were, during synovitis, quite inert, and that their ulceration was caused by a rodent action of the hypertrophied fringes and pannus-like prolongations from the inflamed synovial membranes.

Thus the joint has arrived at this state: the two (or, in some instances, three) bones are no longer closed at their ends, either by cartilage or a continuous plate of bone; their cancelli, on the contrary, lie open, and from them sprout granulations, which, with those from the synovial membrane, form one mass. The unsealed bones are conjoined by a mass of granulations, in the midst of which is a cavity, usually containing pus, and there are generally also more abscess-cavities among the inflammatory tissues. The capsular or other ligaments are likewise invaded by this same material, and are thereby softened and loosened, and may in time become absorbed. It is, however, rare that the mere proliferating (granulating) mass goes on to thus entirely occupy the place of the former joint, without, in some part, undergoing either degenerative and destructive, or reparatory and consolidating acts. Thus there may be abscesses in various parts, accompanied or preceded by fatty degeneration, or, more rarely, by spots of caseation; or, again, we may find here and there a tendency to form cicatricial-like, fibrous tissue throughout a greater or less extent of the growth. All these changes we will leave for the present, in order to study certain phenomena that accompany synovitis, and, more especially, the ulceration of cartilage.

We have seen (page 264) that in acute synovitis the flexor muscles shorten very considerably, thus producing persistent flexion of the joint; this is at first merely *contraction* of a reflex character—that is to say, the σαρκος is actively involved—but after a time the sarcolemma and other fibrous elements shorten themselves (since the muscle is never elongated), becoming thus adapted to the decreased length. This fibrous shortening is that which I, many years ago, named "*contracture.*" If disease were now to cease, there would result a limb bound into a certain angle by a fibrous band; that angle can be diminished, that is, the limb can be further flexed, but it cannot, unless force be employed, be increased. The disease, however, and with it the muscular contraction, may not now cease; on the contrary, the σαρκος, with fresh vantage-hold on the shortened fibres of its sheath, acts with greater vigor, drawing the distal bone into a still sharper angle, and itself becoming more contractured. This form of shortening is always accompanied by fibrous degeneration of the muscular element, and the affected muscles, therefore, waste very considerably; the muscles, more especially the flexors, soon become little else than fibrous cords. The extensors, on the other hand, which are not thus affected by reflex tonic contraction, nor, therefore, by contracture, remain flaccid, and are prone rather to fatty degeneration, which, however, does not occur so early in the disease.

But another effect, besides flexion, follows these muscular acts at certain joints, more especially at the knee. For since the cartilages are, in part, destroyed, and the shape of the bone-ends modified, a certain loss of substance has been thus produced, which, by approximating certain points of bone, renders the ligaments somewhat looser. Moreover, those structures are, as we have seen, involved, and, more or less, disintegrated by the granulating process, which softens them and causes their fibres to be still more flaccid. In consequence, the continued drag which the muscles exercise, as above

Fig. 637.



Consecutive or pathological dislocation of tibia backwards at knee.

described, upon the distal bone, produces not merely flexion, but a gradual gliding of the lower joint surface upon the upper, towards the side of flexion, producing pathological dislocation, or, since it is rarely complete, subluxation.[1] At certain joints, dislocation may occur in other directions than those of flexion; for instance, the tibia may be displaced outward on the femur, this being due to unusually powerful action of the popliteus muscle. Now when these contractures have persisted a certain time, another set of neuromuscular phenomena, commonly called starting pains, arise; they are clonic spasms affecting the muscles about the joint, or, when severe, those of the whole limb. Their commencement tallies, in point of time, with the hyperæmia of the cancellous bone-ends that accompanies cartilaginous inflammation. I proved this coincidence many years ago, and a long course of careful observation has confirmed that view. They appear to me exaggerated manifestations of that muscular sense that warns us of excessive pressure on joint surfaces, or of pressure in unusual and hurtful directions, and are like that general spasm of all the muscles of a limb which occurs when a false cartilage, intruding between the bones, causes violent pressure on points of their surfaces. Thus, since the period when the bone-ends become hyperæmic is not fixed, so is the advent of starting pains variable. It is always earlier in joint-diseases that begin in the bone, than in those that commence in the synovial membrane. The pains are accompanied by increasingly rapid wasting of the limb: during mere quiet contracture it was chronic; during starting pains, and in direct ratio with their severity, it becomes acute.

The etiology of these pains, the way in which hyperæmia under the cartilage may produce them, is very difficult to elucidate; they appear to me to be due to perturbed reflex action of an excited spinal cord, occurring at a time when the cerebral controlling power is withdrawn. Thus, sleep, though we think of it chiefly as it affects the mind, must also influence the spinal cord, but more slowly. Many persons twitch when going to sleep; this happens chiefly after overfatigue, or when the health is somewhat depressed.[2] Now, the flexor muscles of a diseased joint are, and have been for some time, in a state of persistent contraction; it must be that those muscles are overfatigued, or in an analogous state, and in all probability a certain district of the spinal cord is overexcited. Twitching of those muscles, therefore (in the period when the brain is asleep, but the cord still awake), is a highly probable event. But this twitch, which is of no importance, or is not remarked, during ordinary circumstances, drives the bone-ends together with some force, and, when they are rendered tender by disease, produces a state of pain, which in its turn causes a more violent contraction. Starting pains, therefore, are the product of unregulated reflex acts, and of joint tenderness. Subchrondric hyperæmia causes additional contraction of the flexors, and thereby a spinal and muscular irritability which renders them liable to twitch with such unusual violence as the morbidly sensitive joint cannot bear.

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[1] The pathological luxation of the hip is, probably, due to other causes besides muscular contraction.

[2] The commencement of many spinal diseases, for example, locomotor ataxia, is marked by severe twitching.

THE THIRD STAGE of strumous synovitis embraces two processes: the one of consolidation and further organization of the granulations, the other of degeneration and destruction. It is, of course, to be understood that either of these, but chiefly the reparative process, may set in without intervention of the second stage; in other words, a strumous synovitis may be cured without ulceration of cartilages. We must also understand that in some cases destructive action will take place at one part, and reparative action at other parts of the same joint.

Process of Repair.—The consolidation of the granulations and their subsequent transformation into fibrous tissue is the same process as that which takes place in the healing of an ulcer, or in the filling up of any gaping wound. This is effected by that gradual change of embryonic granulation-cells into caudate and connective-tissue cells (placoids of Klein), then into spindle-cells, and lastly into cicatricial fibrous tissue.[1] By this means, if the process go on *pari passu* throughout the whole region of the inflamed joint, the condition of things is changed: the bones, which were formerly separated rather than united by the soft granulations, are now bound together by a firm fibrous tissue which springs, as the granulations sprung, from all the cancelli and from their opened cavities, as well as from the outer case of the bone and from the joint capsule; thus the bones may be said to terminate in a short, thick rope which binds them together, and of which the soft parts around (all that were involved in the disease) form the outer parts; this is termed "false" or "fibrous anchylosis." If, at a later period, this cord ossify, the anchylosis becomes "true." Or, on the other hand, if cure take place before ulceration of the cartilages and destruction of the bone surfaces has occurred, the resulting cicatricial tissue forms a hollow or tubular fibrous bond of variable thickness and strength, according to the amount of previous disease; this "thickening" may be a considerable impediment to motion. Sometimes a portion of the joint surface near the edge of the cartilage may have been destroyed, and then a process of the fibrous tissue intrudes a certain way into the joint, projecting like a pilaster from a wall. Such processes, which are not very properly called "adhesions," generally impede mobility very considerably.[2]

Process of Degeneration.—Although strumous synovitis is a very slow disease, and the tissue product very indolent, yet this is not very durable; some change must take place, and if in a given time repair do not set in, a destructive process must inevitably commence; caseation is not very common, and occurs only at small points; fatty degeneration of the cells and suppuration are more usual. These two are always somewhat commingled, but very often certain tracts or spots of the tissue may break down into abscesses, with but little pathological change; wide or large suppurations, on the contrary, are, as a very general rule, preceded by much fatty degeneration, which in bad cases invades the tissues almost suddenly. This condition is marked at its commencement by a greenish coloration of the granulation-tissue, and afterwards by a dirty, muddy hue. Suppuration of one part of the granulation-tissue is generally accompanied by its spread further and further from the centre, and this more recent growth may in its turn suppurate, leading either to large pus-formations in various parts of the limb, or to isolated or slightly connected abscesses in what was the cavity of the joint, near to that locality, or at variable distances, both in the soft parts or in the bone. These may be termed respectively, "intra-articular," "periarticular," "adjacent," and "intraosseous."

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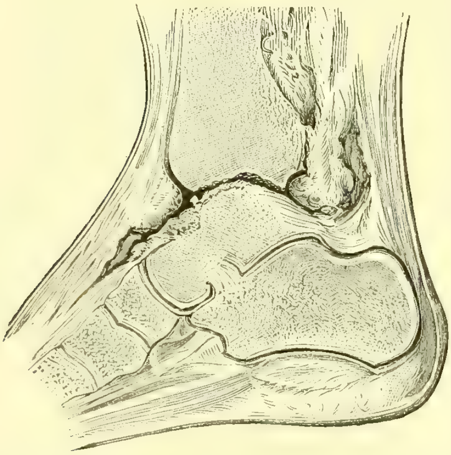
[1] A fuller account of this process than is desirable here, will be found in this Encyclopædia, Vol. II. pp. 16–20.

[2] I prefer to call these "fibrous bonds;" true adhesions between joint surfaces, comparable to adhesions of the pleura, are excessively rare.

Fig. 638.



Intra-articular, periarticular, and adjacent abscess in a case of synovitis of the ankle.

Of *periarticular abscesses*, it may be said that they sometimes originate in the passage outward from the central cavity of a little pus, which sets up or encourages suppuration in its new position; but they more often arise independently, having for some time no communication with the remains of the joint-cavity. *Adjacent abscesses* of a more superficial sort, namely, immediately beneath the deep fascia, separating that structure from the muscles beneath, are not uncommon in this disease, and they may, especially if the pus be of slow formation, burrow a long way under the tough, fibrous structure. A deeper form, namely, among the muscles and more especially that sort of adjacent abscess that travels along the bone, is much more common in osseous than in synovial joint-disease.

Intraosseous abscess of any large extent or significance is not usual in chronic synovial disease, although small foci of suppuration close to the end of the bone are often found; suppurative softening of the epiphyseal line, giving rise to diastasis, is also unusual in synovial disease, though it is not so uncommon when the disease commences in the epiphysis itself.

Any one of these abscesses may open outward; even the intraosseous, communicating after a time with one of the other varieties, gains indirectly the surface. When, however, the pus arrives at the deep surface of a fascia it does not, unless of very rapid formation, continue its course directly outward, but burrows some distance—passing sometimes along the course of a tendon, sometimes gliding in an intermuscular groove—according to the anatomical arrangement of the part. Even when it reaches the skin, slowly formed pus does not quickly penetrate that structure, but spreads itself in a radiating manner from the spot first reached, sometimes to a considerable distance.

These processes of fatty degeneration and suppuration may be almost rapid enough to be termed acute, even though the preceding stages have been very slow; they may too involve a large part of the limb, causing considerable destruction. In the mean time, the joint, loosened and broken down, becomes more and more disorganized, and the bones displaced; afterwards, if allowed to continue and if the patient survive, fragments of ligamentous or osseous tissue come away with the discharge. Rarely, however, are these forms of joint-disease permitted by nature or by art to reach these ultimate limits. Operative measures are employed, or, these being inapplicable, a kindly death terminates the patient's sufferings.

For the local changes above described do not stand alone, but on the contrary are accompanied, and perhaps in great part produced, by considerable deterioration of the general health. As with, or previous to, any reparative changes, marked amelioration of the general condition may be verified, so, on the contrary, the commencement of degeneration or suppuration may often be inferred from a rapid deterioration of general health. Indeed, it may be taken as true that an ill state of health, or defective hygienic arrangements, will prolong this form of joint-disease, and conduce to its most untoward terminations. The patients are strumous, certain of them having a tendency to, or being actually affected with tuberculosis, and many a child who first comes under care with some articular malady, will soon after require to be treated for phthisis, or will succumb to tubercular meningitis.

Symptoms of Strumous Synovitis. (*First Stage.*)—Strumous synovitis is far more frequent in persons below twelve years of age than later in life. When it does attack older persons, it most commonly affects one of the smaller joints, while in children it chooses one of the larger articulations; the numerical order of their proneness to this form of disease is as follows: the knee, the hip,[1] the ankle and elbow (equal); the least often affected of the large joints is the shoulder.

Various conditions may be found immediately preceding this form of joint-affection; for instance, measles, or other exanthem, with slow recovery, ill-defined and apparently causeless loss of health, and traumatism, are so frequently mentioned as occurring just before, that they all appear in different cases to act as exciting causes of joint-disease; but a certain number of patients are in the best health (save as regards diatheses), rosy, plump, with excellent appetite, etc.

If injury produce the malady, the symptoms of an acute or subacute synovitis—if measles or scarlatina have caused it, those of exanthematous synovitis—may precede the characteristic symptoms of the strumous disease. One of these, perhaps the chief, is the sort and character of the *swelling*, which is shapeless, uniform, and rounded. It is not like that of an acute synovitis, most evident where fibrous investment of the joint is weakest, nor is it marked by the passage over it of tendons, nor by the constricting force of ligaments. It is simply a swelling, not merely void of any special form of its own, but covering and concealing the form of parts beneath—the bones, their processes and depressions, the insertions of tendons and of ligaments, etc.

The consistence of this tumefaction is soft and doughy, not very elastic, and not pitting; it does not fluctuate, though by the uneducated finger it might be held to do so in certain rather softer parts, for some portions are softer, others a little harder, than the general mass;[2] the harder are not defined from the softer portions by any distinct edge, but any particularly soft spot is usually pretty definitely marked off from the rest.

The skin is by no means of that red typical *color* given as a symptom of inflammation; on the contrary, it is either the same as that of the neighborhood, or is white—whence Wiseman's name of "white swelling." In the worst cases, a few veins, flattened against the skin by the pressure from beneath, are plainly marked by blue, tortuous lines; they are only found when the granulation-tissue has grown with unusual rapidity, and in such cases the swelling is soft, having greater likeness than in other cases to fluctuation.

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[1] I believe this to vary somewhat at different ages, and that in very young life the hip is more frequently diseased than the knee.

[2] I desire here to lay especial stress on the way this swelling covers up and conceals the markings of the bones; it is by this peculiarity, more especially, that the synovial is distinguishable from the osseous joint-disease.

Such an appearance, therefore, is of bad omen, and signifies considerable tendency to fatty and suppurative degeneration.[1]

Pain is, in the first stage of strumous synovitis, a very variable symptom. In many cases it is at first absent, and the disease may only be discovered by means of the swelling, or by some sign of lameness; this appears to be produced rather by some inaptitude in movement—an inability usually to quite straighten the joint—than by any pain. If at this period the surgeon endeavor to straighten the limb, signs of pain will be elicited; but he may flex it, though perhaps not to the full extent of its normal movement, without causing any pain. When the disease has continued a certain time, the joint becomes somewhat painful, but throughout this stage not severely so, a dull aching, or a sense of distension or of gnawing, being alone complained of. In two cases, one observed in 1858, and one during the present year, 1882, a feeling of considerable cold in the joint was noticed. I am not inclined to attach importance to the sort of sensation experienced, but it should be noted that considerable suppuration occurred in both the instances last referred to.

Another sort of pain, viz., *tenderness*, that is, sensitiveness to pressure, must be especially noted. During the early part of the disease, the joint may be handled without producing any pain; but very soon a certain spot, peculiar to each joint, is found to be impatient of pressure, and in most joints this spot is that to which afterwards the chief shock of starting pains is referred. In the choice of treatment it is very important to be acquainted with these localities: they are:—

At the *shoulder*, while the hand is lying on the anterior aspect of the trunk, at the front and outside; that is, in a line drawn straight down from the acromio-clavicular joint for about an inch.

At the *elbow*, behind the joint, where the radius is articulated to the humerus.

At the *wrist*, at the back, just outside the extensor indicis tendon.

At the *hip*, if there be any pain at the commencement of the disease, it is at the inner side of the thigh, just behind the origin of the gracilis muscle; afterwards it shifts to a more constant place, behind the great trochanter.

At the *knee*, the tender point is on the inner condyle, about half an inch from the edge of the patella.

At the *ankle*, it is in front of the outer malleolus, about the place where the peroneus tertius muscle crosses the joint.

These spots in their respective joints continue tender while the formative, or rather the proliferating, processes are sufficiently active to be properly considered as inflammatory. When that activity has ceased, or has so abated as to remove the action from the inflammatory class—that is, when the tissue does little or nothing more than maintain its vitality—the tenderness of these localities ceases.

Heat, either local or general, is in strumous synovitis absent; the surface-thermometer, applied to the joint, does not rise any part of a degree, nor is there in this stage any pyrexia.

But the symptoms of the disease are not confined to the immediate vicinity of the joint; the limb is flexed, and the limb-segment above, and to a lesser extent that below, become wasted. Any attempt to straighten the joint gives pain, and causes the flexor muscles to start into strong relief; they may be felt tight and hard beneath the skin. Quite at first they feel like, and merely are, muscles actively contracted, but after a time they come gradually to resemble cords put on the stretch. As the disease goes on, the joint, unless prevented by art, becomes more bent, and at the same time more painful; the child is more cautious in using the limb, and perhaps wakes up occasionally at night, crying.[1] The surgeon, who, if careful, will have kept measurements of the part, finds the joint increasing, the limb wasting, and the child looking more worn and out of health. He will be aware that his patient is getting worse, though no new symptom has arisen.

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[1] This marking of veins must not be mistaken for the more copious network of malignant disease.

The *second stage* is now imminent, its advent being marked by *starting pains.* These have been already referred to (see p. 306), but they merit here a fuller description, since they are most frequently met with and most perfectly developed in those forms of joint diseases which originate in struma, not because the diathesis has any direct connection with this symptom, but because scrofulous diseases attack more especially children in whom the spinal motor system is very mobile. At first, and often throughout the case, these pains only come on when the patient is sinking to sleep; he is quite placid, and apparently not suffering, when suddenly he twitches as though startled, and breaks into a sharp scream of pain, crying for some time before he again tries to sleep; this may be repeated several times before at last complete unconsciousness comes on. Some children dread these starting pains so much that they keep themselves awake as long as possible; but it is difficult, since means of comparison are wanting to such young persons, to make out exactly what the pain is like.[2] It seems as though it did not at once subside, since (but this in some cases may be mere alarm) the crying usually goes on for some time before the child tries to sleep again.

This symptom may be taken in strumous synovitis to indicate commencing ulceration of cartilages.[3] Moreover, the extent and intensity of these pains are the measure of the amount and rapidity of the ulceration.

When this symptom has lasted a certain time, another, which I have been accustomed to call *intra-articular tenderness*, makes its appearance. My observations, clinical and anatomical, lead me to believe that this symptom never occurs unless, the articular lamella having given way, the bone cancelli are open to the joint. In seeking for this phenomenon, very great care is necessary to avoid any movement of the joint, which often causes pain, but not of the sort in question. Neither must alarm or dread that something painful is about to be done, be mistaken for real pain.

About this time generally, but sometimes during the latter end of the first stage, the distal bone of the joint may be *moved* on the proximal one *in abnormal directions.* The tibia, for instance, may be made to glide sideways, or to rotate a little on the femur; the ulna will also glide laterally on the humerus, etc. This symptom is, according to its extent, of evil augury; occurring early, it shows unusually rapid invasion and softening of the ligaments; occurring at a later period, and to a greater extent, it shows that the tissues have been much involved, and that degeneration has set in.

Both these symptoms may be combined with *subluxation* or *complete dislocation*,[4] which is much more common and of earlier occurrence at certain joints than at others. In many cases the shoulder is slightly displaced forward. The ulna at the wrist is very prone to be thrown backward. The hip and the knee are both very subject to pathological dislocation; in the former this is generally complete, in the latter incomplete, and very early; indeed, a certain amount of backward displacement of the tibia is, even during the first stage, usual, unless the case have been skilfully treated.

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[1] This is not the sort of pain to be described hereafter; the waking is not with a sharp, sudden cry, but there are at first restless movements in half sleep, and then a slow commencement of weeping, which usually is before complete awakening.

[2] An older patient described them to me the other day as being like what is felt when a dentist thrusts a hard instrument against an inflamed and carious tooth.

[3] We shall see hereafter that in epiphyseal joint-disease it has not quite the same meaning, since hyperæmia of the joint-end is in that malady a very early condition, not a secondary effect of chondritis.

[4] Some bones, as the ulna at the elbow, are, by their formation, precluded from pathological luxation.

Joint-crepitus.—Very often, when the limb is moved either in a normal or abnormal direction, a distinct, bony crepitus is felt. This symptom, when it occurs, is direct evidence that the cartilage has disappeared from both bones. Its absence cannot be taken to indicate non-ulceration with any certainty; for granulation-tissue may prevent the contact of the otherwise bared bones, or, what sometimes though rarely happens, the loss of substance on one bone may not be opposite to that on the other. A nutgall-crepitus, that is, one which does not quite feel like two bone-surfaces rubbing together, may indicate cartilaginous ulceration on one bone only; but it is hardly distinguishable from fibrous or ligamentous crepitation. In some cases crepitation is present during a certain period, and may then disappear—either to reappear, or to remain permanently absent. This last event indicates a tendency to amelioration of the local condition by the occurrence of fibrous anchylosis.

At this time *abscesses* within the joint or elsewhere may be developed; although they are more particularly characteristic of the third stage, yet their commencement is often here.

The symptoms of the *third stage* are either such as mark consolidation and repair, or such as indicate degeneration and further ravages.

Reparative processes mark their advent always somewhat slowly, but more especially so if they have fortunately commenced during the first stage of the disease, or, indeed, during the earlier part of the second, before ulceration of cartilage has gone very far, or before abscess has formed. In the former case, the slow amelioration is marked by an improvement in the general condition; the child's sleep is less perturbed; his appetite is less capricious; he eats in a more business-like manner, and no longer requires to be tempted with tid-bits or constant variety; his complexion is clearer and brighter; and the tell-tale dark marks under his eyes disappear. While these improvements are taking place, the disease is generally in that state of interregnum above referred to (p. 303); the joint no longer increases in size, and after a time becomes harder; the special points of tenderness (p. 310) are no longer painful on pressure; ultimately decrease in size may be verified, and the bone appears less distant from the surface, while its elevations and depressions reappear. The amount of this resumption of form depends on the previous degree of swelling, for the greater part of the inflammatory products do not disappear; the deeper structures still remain covered by them, only now more fully developed, and therefore occupying less space. If before repair has begun the cartilages have ulcerated, we may add to this account that, simultaneously with the improvement in general health, the starting pains diminish both in frequency and intensity.

When abscesses have already opened outward, the gradual diminution and cessation of discharge is very marked; but still more striking is it to see the exuberant sprouts of granulation slowly recede within the openings; they do not shrivel and disappear, but are really withdrawn, as a snail retires into its shell. This is due to the contraction which the deeper inflammatory products undergo during fibrillation—the indication of which may be seen for years afterwards in the depressed cicatrices which such abscess openings leave behind.

This fibrillation and hardening of the granulation-tissue is the first step towards false anchylosis, if the whole joint and its surroundings have been occupied; to mere thickening and restrictions of movement, if only the perisynovial district has been involved; its progress is marked, first by disappearance of any pre-existing abnormal mobility, and then by increased stiffness of the limb. When the process is complete, the diseased joint is nearly always smaller in circumference than the sound one. This is due in great measure to the cicatricial contraction of the newly-formed tissues, but may also be owing to arrest of epiphyseal growth. That subject will be more fully discussed hereafter.

The *destructive processes* are at first often masked; they may not attack the whole area of disease, but only localities here and there, while elsewhere actions of an entirely different character may be going on. Indeed, it is in some cases, and for a certain time, difficult to say towards which goal the action is tending. The key is to be found partly in the local, but also very much in the general conditions. While the hectic decreases, or, at the least, remains stationary, some hope may well be entertained; but if the thermometric fluctuations increase, showing a generally higher temperature, but with wider range between morning and evening, the prospect is bad. This condition of temperature is accompanied by a more capricious state of the appetite, greater restlessness, and probably profuse night-sweats. Diarrhœa also sometimes supervenes. The state of the spleen, liver, and kidneys must be carefully investigated. The local signs are increasing softness and size of the joint, while the limb below, as well as above, wastes more rapidly. I have also learned to look upon a desquamative condition of the skin over the joint, and immediately above and below, as very suspicious. The desquamation is not furfuraceous, but in large flakes, the size of the flat surface of a split pea, and these are often of a light-brown color, a tint darker than the skin of other parts. The bones become more and more movable in abnormal directions, the malposture continuing nearly always in the direction of flexion, and the subluxation increases. At last any doubt is set at rest by the appearance of an evidently fluctuating spot, near to or just beneath the skin; yet even now the pus does not rapidly cause distinct pointing, but a slightly pink hue, which, although it very rarely assumes the deeper tinge seen in acute forms of abscess, gradually deepens a little, and at the same time spreads. Examination of such a spot will show that the pus is separating the skin from the underlying tissue. When an opening, natural or artificial, is made, a good many flocculi come away with the ill-formed pus, and soon afterwards fresh granulations, pale-yellow and pus-sodden, crop out, and generally overlie the skin all around the opening. The pus then does not escape, as in the sinuses of caries, by a central opening, but by various interstices in the granulations, and by the chink left all around between them and the edge of the skin. If a probe be passed in here, it may, as a very general rule, be carried round under the corium a considerable distance from the wound. The skin is "undermined." There may be several openings of this description, sometimes even a long way from the joint. As a rule, they are chiefly on the limb-segment below, but also are not uncommon on that above the joint, where, however, they are usually less distant.

As the disease still goes on, the hectic and exhaustion increase; yet patients do not die of joint disease alone, but of affections of the viscera. Very many young children succumb to tubercular meningitis, which, however, usually destroys life at an earlier stage of the malady than that to which we have traced strumous synovitis. Those who have survived thus far usually die either of tubercles in the cerebral meninges or lung, or of lardaceous disease of the abdominal organs (liver, spleen, and kidneys). When the presence of the latter complication is feared, the condition of the urine, the color of the skin, and the position of the two first-named glands, should be carefully investigated from time to time.[1]

TREATMENT OF STRUMOUS SYNOVITIS.—Struma, as a constitutional condition, must be treated according to the type which in each case it assumes; the delicate, thin-skinned type requires the use of tonics, such as iron, quinine, maltine, and cod-liver oil, while if iodine in any form be given, it must be used cautiously and in combination with the other remedies. But the other form, that with thick connective tissues, is not benefited by the administration of the nutritive tonics. Cod-liver oil is especially, in my experience, useless, if not injurious in these cases, but occasional purging,[2] and the use of iodine, the mineral acids, and vegetable bitters, are indicated. But this is hardly the place to describe the treatment of such constitutional conditions; I wish, however, to give a broad outline of those methods which appear to me most suitable.

The *local treatment* of a commencing strumous synovitis consists chiefly in rest, care being taken that the limb is in good position. In a very early stage of the disease, there is no difficulty in securing these desiderata. Upon the limb, held by an assistant in the proper posture, a flannel or Domett bandage may first be applied, and over this may be moulded a poro-plastic or leather splint; or if it be preferable, as it is in some cases, a plaster-of-Paris bandage may be employed. But it must be pointed out that as cases even in their earliest stages differ, so there are decided reasons for choosing one or the other of these appliances. If the disease have commenced in a slow, painless enlargement, and if the swelling be soft and the signs of struma strongly marked, the local disease is likely to be of a bad type. Hence, as probably some local treatment will be necessary, I should prefer in these cases a removable apparatus; while when the disease has begun more rapidly, perhaps following some traumatism, and when the signs of struma are not strongly marked, we may, especially if the tumefaction be moderately hard, use an immovable appliance, trusting to mere rest as a curative measure. But here again we are confronted by another difference. There is no doubt that the child's condition is not improved by confinement to bed; if the disease be in an upper limb, this subject presents no difficulty, but if in a lower, we must combine perfect rest of the diseased joint with bodily exercise. To American surgeons is, I believe, due the first idea of putting a patten or high shoe on the sound limb, giving the child a pair of crutches, and letting him get about with the foot of the unsound leg carried some inches from the ground.

These appliances and aids are those which I use in the early stage of strumous synovitis, and whether I apply a double case of leather or felt, or a starched bandage, I always let my patients get about at the earliest possible period; never confining them to bed if the disease be in an upper limb, and only for a few days if it be in a lower. The rest afforded by properly made appliances of this description is perfect; nor have I ever found any difficulty in the details. But if the surgeon be called to the case when already contraction of muscles has produced a certain amount of fixed flexion, he must adopt measures to reduce the limb to a proper posture. This may be done either suddenly or gradually. The former plan may be most advantageously employed at almost every joint, with the exception of, in some cases, the knee and the hip. It simply consists in giving to the patient an anæsthetic, and with the exercise of only slight force putting the limb into the desired posture, and fixing it by means of a rapidly drying plaster-of-Paris bandage, which must be allowed to harden sufficiently before sensibility returns. I have insisted upon slight force, because I deprecate at this stage any replacement by much stretching; if ligaments or muscles be by too great an exercise of power rendered tense, they cause the two joint surfaces to press injuriously on each other. It is far better to put the limb nearly into the proper posture by gentler efforts; to retain it there for about ten days; and then to remove the bandage, and make a second attempt. Very often, even without an anæsthetic, the joint can now be easily reduced to a good position; if not, ether may again be given. The avoidance of an over-amount of force is especially to be inculcated in diseases of the knee-joint, which, under such circumstances, is very apt to suffer posterior subluxation. The gradual reduction in still early malposture may be carried on in the same way, but without anæsthesia. An assistant holds the limb as nearly as possible in the required posture, while the surgeon fixes the appliance; in a few days a much further step may be gained, and so on until perfect posture is acquired. This plan answers admirably for the elbow and wrist. At the ankle, it sometimes happens that the sural muscles produce considerable extension of the foot; the position of their tendon, so far behind the joint, and the peculiar ease with which those muscles are thrown into painful cramp, render it sometimes advisable to divide the tendo Achillis previous to reduction, rather than run the risk of the pressure which would be produced by a forcible replacement. This is the only tendon which ought to be divided for the purpose in question.

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[1] For further considerations regarding pulmonary or cerebral tuberculosis and lardaceous disease, see p. 360 *et seq.*

[2] In this condition the intestinal canal is frequently clogged with viscid mucus.

But of all joints, the knee requires in these manipulations the greatest care,[1] and presents the greatest difficulty. If the flexion be pretty strongly marked, and endeavors be made to place the limb straight, the upper end of the tibia may slowly glide back as the lower end comes forward. The surgeon finds that he is producing a partial dislocation backward. Sometimes that malposition already exists to a slight extent, and to attempt rapid replacement would then be a decided error. Hence, in strongly-marked flexion, or when some displacement is already present, it is far better to trust to weight or elastic extension. This may be effected by a strip of plaster applied on both sides of the leg, so as to form a loop below the sole, and rendered more firm by circular strapping or bandaging. The loop is fastened to a cord which plays over a pulley at the foot of the bed, and to the other end of which a weight is suspended. Dr. Sayre recommends that another band should pass under the upper part of the calf, the weighted cord attached to which runs almost perpendicularly upward to a pulley in the ceiling. I have not found this efficacious; it tends to keep up the flexion, and cannot act in reducing or preventing backward displacement unless a third force hold down the lower part of the femur.

I have found a simple "extension splint," acting by elastic force, extremely efficacious. It is like a Desault splint, with the addition that between the forks a pulley plays on a straight axle, and from the ends of the fork a steel wire projects inwards, carrying a pulley which works below the sole; at the upper end, and projecting outwards, is a steel bracket, also bearing a pulley. This splint should reach from a little below the axilla to about four inches lower than the foot would be if the limb were straight. Plaster looping under the sole is applied as above; the cord passes from the loop over the lowest pulley, and, running up outside the splint, ends in an "accumulator," the upper end of which is supplied with a wire hook. A perineal band embraces the upper part of the patient's thigh and the splint; it carries a cord, which, passing over the upper pulley and down outside the splint, ends in a chain; now, by stretching the accumulator so that the hook can be hitched into any chosen link of the chain, the appropriate amount of extension can be produced. There is no occasion for bandaging, save around the lower part of the chest, until the limb is nearly straight; indeed, the apparatus will work perfectly without any bandage at all, but an attendant must, as the knee straightens and the foot descends, hook the accumulator higher and higher on the chain.

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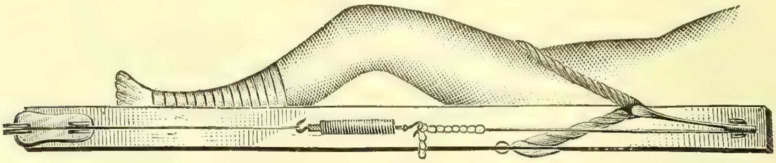
[1] I do not even except the hip, which forms, however, the subject of a separate section.

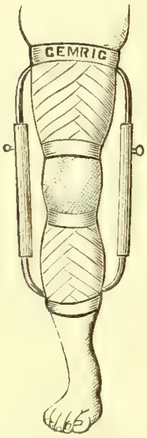
Fig. 639.



Barwell's extension splint.

A case which has advanced far enough to require correction of the sort described, will, in all probability, require somewhat lengthened treatment. At first, while the inflammatory symptoms are pretty strongly marked, and advancing from the joint into the surrounding parts, perfect rest must be secured by some of the means indicated for the treatment of acute synovitis. If the elbow or wrist, and sometimes if the shoulder, be the seat of disease, it will probably not be advisable to keep the patient in bed more than a few days. But if the disease be in a lower limb, a longer stay in the horizontal position becomes necessary. As soon, however, as the more pressing symptoms of inflammation have subsided, the patient must be got up, and be allowed to move about with such appliances as shall keep the affected joint at rest, while permitting exercise of other parts of the body.

Fig. 640.

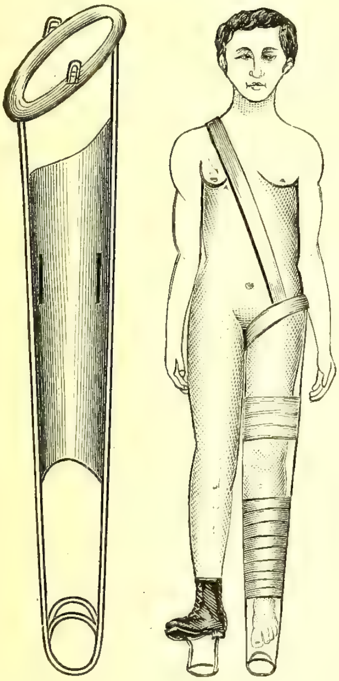


Sayre's extension splint for disease of the knee-joint.

American surgeons have worked very well and successfully in this direction. Taylor's long splint, or Pancoast's apparatus, originally devised for the hip, but likewise applicable to the knee, if additional straps higher on the thigh and lower on the leg be superadded, answers this indication extremely well. Dr. Sayre's extension method is, I believe, much used in America, but in Europe the use of plaster for making extension has not been found very successful; partly because of skin irritation, partly because of loosening and the necessity for frequent renewal. Thomas recommends the same splint which he uses for knee-disease in bed, to be also employed in walking with crutches, as shown in Fig. 641; the ring at the lower part being turned transversely so as to give sufficient width to the tread. The instrument, however, is somewhat heavy and clumsy for use in this way. Its chief point of improvement over Taylor's and Pancoast's appliances, lies in the substitution for their too yielding and flexible pelvic and perineal bands, of a firm metallic ring encircling the upper part of the thigh, and in the furnishing better support by means of the leather apron instead of the too narrow calf and thigh plates.

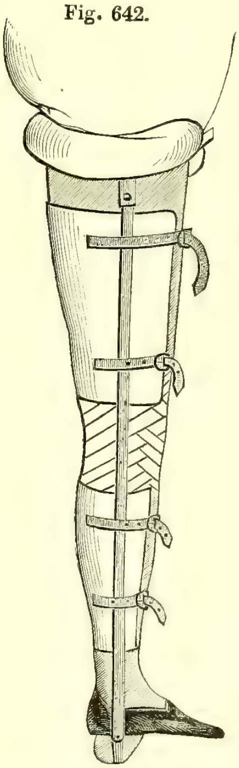
A very valuable apparatus is one to which, during the International Congress of London, Dr. von Wahl, of Dorpat, drew my attention, and in the devising of which he bore some part, though the chief merit of the invention is justly ascribed to Dumbrowski.[1] The metallic thigh-ring of Thomas is retained, but, being made of steel, is capable of being opened to receive the limb, and is provided with a strap in front to secure it firmly. The apparatus is thus made: first, on the thigh and leg, and also, in disease of the ankle, on the foot, are moulded splints of felt, soaked in water-glass; these entirely encircle their respective portions of the limb, only leaving a slight gap in front. Accurate measurements are taken of the length of the different limb-segments, and strips of sufficiently strong metal are cut accordingly, one for the outer and one for the inner side, reaching from the thigh-ring to the malleolus; when the knee is affected, no hinge lies opposite that joint, but one is placed at the ankle, the rods below which are united a sufficient distance beneath the foot by a sufficiently broad sole plate. If, on the contrary, the ankle is the diseased joint, a hinge lies opposite the knee, but there is none corresponding to the ankle. These appliances being ready, and the water-glass splints dry, these latter are removed from the limb, and are riveted to the metals; straps are then sewn on, and the mechanism is ready for adaptation, which is effected by a fresh soakage in water-glass, and by bandaging and strapping on the limb. When all is dry, the patient is allowed to walk about; of course, at first, a couple of sticks, or even crutches, must be used for the sake of balance, but they may very soon be discarded. If the instrument have been rightly made and applied, the foot does not come to the ground; the weight falls on the sole plate beneath the foot, and is transferred by the metal rods to the ischium. The advantages of this splint over

Fig. 641.



Thomas's splint for disease of the knee-joint.

Fig. 642.



Dumbrowski's splint for disease of the knee-joint.

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[1] Inaugural Dissertation, Dorpat, 1881.

any other with which I am acquainted, are that it fixes perfectly the diseased joint, leaving the others free, and obviates all weight-pressure on the joint-surfaces; moreover, after a very little practice, the patient is able to walk steadily and securely without crutches, thus leaving his hands free for employment or amusement. I can speak from some experience of the great efficacy and value of this splint; and the more I see of strumous joint disease, the more evident does it become to me that fresh air and exercise are great aids, if not essential to its cure.

But occasionally, when the limb is in or has been put into good position, and when all has been done to prepare it for some such splintage as has just been described, inflammatory symptoms and pain do not sufficiently abate. This mostly happens when neglect has allowed the disease to advance, when the strumous habit is strongly marked, or when bad food and hygiene have depressed the health. Starting pains show that the bones are becoming involved, and perhaps increase of the soft swelling marks a tendency to abscess.[1]

Among our most potent remedies must be mentioned strong but carefully applied pressure. This may either be carried out by using an adhesive plaster—the emplastrum resinæ, the emp. ammoniaci c. hydrargyro, the emp. plumbi iodidi, or, if a more rubefacient action be desirable, the emp. cantharidis[2]—or the joint may be compressed with a bandage of elastic webbing, which I prefer for this purpose to the whole-rubber bandage of Martin. Care must be taken not to exercise such constriction as to produce œdema of the limb below; and it is always advisable first to bandage the parts below the joint. Stronger and more even compression can be obtained if the part be first covered with a tolerably thick layer of cotton-wool; and this keeps purer and sweeter if a little spirit of camphor be sprinkled over it. Careful bandaging of this sort will remain firm a long time on the splint.

If these methods be successful, one of the locomotion splints may be applied, pressure being still maintained. In some cases nothing more is needed, but in some there comes a time, when all inflammatory symptoms have subsided, when the special points of tenderness no longer give pain on pressure, and when motion within certain limits produces no discomfort, and yet the swelling persists, nor does it become, in any appreciable degree, harder. Under these circumstances, the parenchymatous injection of tincture of iodine is often valuable. The parts are in the same state as an indolent ulcer, with soft, flabby granulations, such as we touch with nitrate of silver or with sulphate of copper. The strength of the iodine solution should be at first thirty or forty minims of the tincture in a fluidounce of water, and this proportion may be in a little time increased up to two or even three fluidrachms; the quantity to be injected is about half a fluidounce, by means of a syringe, like, but larger than, that used for hypodermic injections. The needle should have lateral perforations, and must be inserted obliquely so as not to enter the joint-cavity. After using about half or a third of the contents of the syringe, it may be somewhat withdrawn, and then directed with a different obliquity; and this proceeding, once or twice repeated, will soak a large bulk of the tissue through a single skin puncture.

Another mode of treatment is by shampooing or rubbing (*massage*),[3] and by making passive movement. In the former, the chief force both of movement and pressure should be centrifugal; but I cannot credit such great differences of effect as are said by some to follow slight variations of the method. Passive movement is invaluable in two conditions—either as a means of stirring into healthy action an indolent tissue that will neither consolidate nor become absorbed, or for preventing close and stiff anchylosis when tissue is consolidating. Used for the former purpose, we should be perfectly sure that actual inflammation has subsided, and should always begin the method cautiously, both as to range and duration. It may advantageously be combined with rubbing, and the limb must be returned to the splint and absolute rest as soon as the sitting is over. The advent of pain or additional swelling, for the joint should be measured before the next attempt, should cause postponement for awhile of the treatment.

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[1] Even these conditions, if slight, need not deter the application of splints for locomotion; but if severe, and more especially if their progress be rapid, it is wise first to lessen or subdue them. For this purpose, the use of flying blisters allowed rapidly to heal, or of nitrate of silver solution (ʒj–ʒiss ad f℥j), or of strong iodine paint, is valuable.

[2] All these are preparations of the British Pharmacopœia.

[3] Mosengeil, Verhandlungen der Deutschen Gesellschaft für Chirurgie, 4ter Cong., 1875.

The other object of passive movement, viz., to obviate fixity of the joint as much as possible during the consolidation of inflammatory products, is a most important part of rational treatment. This may be intrusted, under surgical direction, to a rubber; but it is preferable to let the patient also take part in the movements,[1] as thereby a certain amount of active muscular exercise is likewise obtained. Thus a great deal may be done by attaching a weight to the limb, and letting it swing. For the knee, a weight of from one to three pounds may be tied below the sole by a bandage or napkin; the patient, seated on a table, lets the weight swing, lifting it a little higher at each gyration, day by day. This brings the leg towards flexion. If it is to be brought to extension, the patient may lie prone upon a sofa, with the lower half of the leg projecting beyond the end, and the weight may be secured in front of the ankle; he is to lift the weight a few inches by the power of the hamstring muscles, and let it fall again, alternately. For the ankle, an excellent plan is to let the patient place the foot on the treadle of a lathe or sewing machine, kept in motion by another person. Sometimes it is necessary that he should steady the knee by pressure with the hands. It is not needful to describe the simple devices for applying these principles to the joints of the upper limb.

The treatment of abscess must, to some degree, depend on its position outside or inside the joint, and also on its more or less rapid formation, especially with reference to the condition of the surrounding parts. An abscess which forms rather slowly within the much contracted joint-cavity, should only be treated by incision or puncture either when tension becomes considerable, or when the pus has pretty nearly approached the surface; in either case, the abscess should be evacuated after one of the methods to be immediately described. Adjacent and neighboring abscesses should be emptied when detected, more especially if the deterioration of the health, and the increased softness and bogginess of the tissues, give evidence that more of the inflammatory tissue is about to give way.

For the kind of pus contained in such abscesses—containing flocculi and tissue-débris—aspiration is useless, and it is better to open such collections with a straight, narrow bistoury, under pressure of an elastic bandage, in the manner already described (p. 274). But if the pus have formed quickly, and if a great deal of the granulation-tissue is evidently breaking down, the best method is to make a free incision, and to pass in the finger and remove from around the abscess all the suppurating and degenerated material; this may even be done on both sides of the joint. Some free oozing takes place at the moment, but by mopping out the cavity with sponges, soaked in a solution of chloride of zinc, forty grains to the ounce, and afterwards by using firm pressure, not only is all bleeding stopped, but union between the sides of the large cavity takes place—and the joint may from that moment progress towards cure, of course with more or less anchylosis. If a sinus be left, or if the narrower opening with a bistoury have been practised, hyperdistension by means of an India-rubber tube connected to a ten-ounce syringe, is often valuable. The fluid employed should be somewhat stimulating—chloride of zinc or iodine solution, as above described; sulphuric acid and water, in equal parts, is too destructive a material for either hyperdistension or washing the joint; some patients have, I am aware, recovered after its use, but a good many have succumbed.

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[1] Bonnet (Thérapeutique des Maladies Articulaires) has described a number of mechanical contrivances, which, for the most part, are of no practical value.

An abscess running along the bone usually communicates with an intra-articular abscess; the worst form is that which runs upwards. In these cases an opening should be established at the lower end (near the joint as a rule), a pad placed over the course of the abscess, and a bandage applied from above downward. Hyperdistension may also be employed, a gum elastic catheter, through which the fluid is to be injected, being passed along to the further end of the suppurating track, and pad-pressure being afterwards applied. Abscesses which run downward come to the surface sooner than those with an upward direction, and they close more quickly; when opened, they should be injected with a stimulating lotion, and a drainage-tube inserted which may gradually be withdrawn and shortened, so that the abscess may heal from the depth toward the surface.

Sometimes, in spite of the utmost care and skill, the disease continues to get worse, and the abscesses discharge freely, débris of fibrous tissue and portions of bone being thrown out with the pus. Yet, though we may despair of the joint, we need not, in many of these cases, despair of the limb; my experience at two homes for cripples has shown me that patients may recover even after much tissue and a great deal of bone have been thus lost. It is scarcely necessary to point out that a good position of the part must be maintained, so that, when repair takes place, the limb may not, at all events, be an incumbrance; nor need I insist on the necessity of watching the case in several different directions. The condition of the lungs should be frequently ascertained, as should the size and state of the liver, and the color and kind of alvine excreta, while the urine should be frequently examined. Patients do not die of the articular disease, but the wasting from profuse discharges, and the irritation, induce tuberculosis of the brain (if the patient be very young) or of the lung, as also lardaceous disease of the liver, kidney, and spleen; these are more fully referred to in another section of this article.

Rheumatic Synovitis.

Rheumatic synovitis or *articular rheumatism*, in those forms which come under the surgeon's care, is a subacute or chronic disease, primarily due to diathetic conditions, but generally excited by exposure to cold and wet. Traumatism, as by a blow or strain, is sometimes superadded, and then appears to act as a direct excitant of rheumatic action.[1] It is humiliating to confess that, after all the attention and care bestowed upon the subject, we do not as as yet know what rheumatism is; but, as always happens when knowledge is scant, speculation is abundant. The lactic-acid, micrococcus, and malarial hypotheses are all without proof; no excess of lactic acid has ever been found in either the blood or the urine, and no microzyme has as yet been detected, nor does the disease comport itself like what we know of maladies thus produced; while the very varying circumstances which attend the occurrence of rheumatic fever, contradict the idea of a malarial origin. Some writers maintain that the malady is a neurosis, localizing it in the spinal cord; and certain points in the natural history of multarticular, acute and subacute attacks, tend to support such a doctrine. For the present, however, we must be content with studying the anatomy and semeiology of rheumatism, and shall be aided in our comprehension of subacute articular affections by first glancing at the phenomena of the acute disease. Acute rheumatism is a fever accompanied by severely painful, multarticular inflammations, and by profuse acid perspirations, during which the very scanty, high-colored urine contains a considerable excess of urea, and also a less excess of uric acid.[1] The blood has the usual alkaline reaction, but contains a superabundance of fibrine, viz., instead of 0.2 (the normal percentage) 1.0 in a 100 parts. The joint-inflammations, though severe, are generally transient, and often metastatic, either to other joints or to internal parts, especially to the heart. The inflammations, whether articular or internal, are especially partial to fibrous tissues; they hardly ever lead to suppuration, but to thickening, to adhesion between opposed surfaces, and to fibrinous deposits and vegetations upon those which are free.

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[1] I was attending the son of a noble family in London, and was asked to look at a footman who had sprained his back and one leg by slipping while carrying a heavy portmanteau; for five days his symptoms were by no means decisive; on the sixth day they developed into a rather severe attack of acute rheumatism. No exposure of any sort could be traced.

The usual course of acute rheumatism is to get well, leaving neither joint-disease nor heart-disease behind; sometimes, however, the heart does not recover, and in some cases the patient appears quite well and remains so for a certain time, and then heart-symptoms slowly begin to show themselves. A similar sequence of events occurs in the joints; most patients get perfectly well,[2] while certain other patients recover from the pyrexia and all constitutional symptoms, though in one or perhaps two joints inflammation continues; other patients appear perfectly well, but after an interval one joint, generally the knee, and occasionally other articulations also, become diseased. In the former of these conditions, all marked pyrexia having subsided, the one or perhaps two joints which remain affected, have within their cavities but very little excess of fluid, and even this is transient; but, on the other hand, there is a good deal of fibrous thickening of both synovial membrane and parts around, and even the neighboring bursæ and tendinous sheaths do not escape. In the most marked cases, the fibrinous effusion lines the inner surface of the synovial membrane, massed into undulations separated by rugæ running across or around the axis of the joint. There is no appearance of fringe-hypertrophy; indeed, these appendages are incrusted and overspread by the solid effusion. There is some near relationship between this form of disease and dry synovitis (page 265), and, as in that affection, rapid anchylosis may take place.

Similar but much less rapid and excessive change appears to accompany disease produced in very rheumatic persons by exposure, or by some slight traumatism, or occasionally to follow, but after an interval, acute rheumatism. At first there is a certain amount of intra-articular secretion, which becomes slowly or rapidly absorbed, giving place to synovial and periarticular thickening, which, though obstinate, also after a time disappears; but the condition is very prone to recur at irregular intervals, generally provoked by exposure, overexertion, or some indiscretion in diet. In still a third form the fluid effusion may not be absorbed, or if it be so reappears very soon, and then continues to increase; this constitutes one species of hydrarthrus.

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[1] The deficiency of water thus excreted is probably in part due to the great quantity eliminated by the skin.

[2] Save a proneness to rheumatic pains on any exposure, and an augmented liability to rheumatic fever.

We will study a little more closely the former of these conditions. At first there is hypersecretion into the joint, but afterwards the by no means considerable swelling is hard and elastic, and evidently fibrinous. Those mere physical acts of inflammation which consist in emigration of leucocytes and proliferation of tissue-cells, are the same in all forms of the process; the diathesis, or the species of inflammation, determines the after-fate and development of that cell-growth. Rheumatic, parenchymatous inflammation tends to produce from the cell-tissue fibrinous material, and that hurriedly. The joint and its surroundings are occupied by a coarse fibrous tissue, formed by closely compacted fibre-cells;[1] this is of a light reddish-brown or fawn color; it is of variable thickness at different points, according in part to duration of disease; it may closely approach the skin, and encroach more or less on the joint-cavity, transforming its inner surface into a series of rugæ, which run in a direction around the joint; these are separated by deep, narrow fissures; the tissue is thickest where normally the membrane is most lax. There are no dendritic, hypertrophied fringes; indeed, the fringes themselves are included in or engulfed by this new formation, which is most developed where the membrane is normally most lax, but especially in the bursa-like prolongations, as in that which at the elbow lies behind the humerus, or in the subcrural bursa of the knee; indeed, I have seen this latter entirely filled up by the inflammatory growth. The tendinous thecæ in the immediate neighborhood are also frequently occupied by the same material, the tendons becoming adherent to their sheaths. In some cases very close fibrous anchylosis, rapidly becoming bony, is left after a short attack of severely painful inflammation.

After a certain time, the cartilages become inflamed in spots commencing on the free surface and extending gradually deeper; the action is a superabundant cell-growth, whereby the hyaline substance becomes split up into coarse fibres. In other points the structures lose their opalescent appearance and assume a light red color, becoming at the same time very thin. If a section be made, it is found that the thinning does not depend upon wear or loss of surface, but upon encroachment of ossification upon the deep layers. In some places, when the case has been of long duration, this ossification extends all through the thickness of the cartilage, so that next to the joint-cavity lies bone which is bright and polished, usually having a reddish tinge, from vascularity. The bone itself is found on section to be much condensed, every plate of the cancellous structure being abnormally thick, and every cavity small (osteosclerosis). Moreover, the inflammation spreads from the synovial membrane to the periosteum, and produces, by reason of its organizing quality, a number of irregular outgrowths from the bony surface—osteophytes—which considerably deform the neighborhood of the joint, and occasionally present considerable obstacles to movement. The surface of the bone, where not studded with osteophytes, has an unmistakable appearance: the natural elevations and depressions, without any describable alteration in shape, are exaggerated, and the small openings and grooves for vessels are increased, so that the bone, though condensed and heavy, appears porous, especially at those parts where vessels pass. In some cases, a peculiar lengthwise marking gives to the bone a surface looking almost fibrous. Of the other forms, the second appears but a slight and intermittent form of the first; a certain thickening of the perisynovial and synovial tissues doubtless takes place, but I must confess myself unable to describe the condition from anatomical examination. Patients do not die of this joint trouble, and no opportunity of examining such a joint, only recently affected, has ever occurred to me. The inferences as to morbid anatomy will be given in the description of symptoms. The third condition, which constitutes a form of hydrops articuli, will be described with that disease; here it need only be said that many rheumatic patients suffer from irregularly remittent attacks of slightly painful fluid effusion accompanied by a little thickening; again and again these may occur, and the fluid be reabsorbed, leaving only some laxity of parts behind; but if the attacks come on in very close succession, and last during a considerable time, a sort of mild hydrarthrus, accompanied by considerable joint weakness, will result.

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[1] I would call especial attention to the characteristic manner in which this tissue, while young, tears in strips with well-marked striation; it is like the sort of tear which takes place in the white matter of a brain that has been a long time in spirit.

SYMPTOMS OF RHEUMATIC SYNOVITIS.—In a certain point of view, a joint left by acute rheumatism, lame, painful, and often deformed, may be regarded simply as incompletely recovered, even although the general disease be well. The course of events is generally as follows: The attack is severe, the pyrexia considerable, and, after a certain time, debility is strongly marked. Usually, during the fever, a smaller number of joints than is customary in so severe a case, are attacked; but sometimes a goodly number may be affected, the inflammation passing rapidly from one to another. In either event one particular joint, generally a large one and among the earliest affected, remains persistently inflamed amid all the fluctuations and variations of other parts. During the somewhat protracted convalescence, all other joints save this one (sometimes two are thus implicated), get well. After a certain period of frequently pretty severe suffering, pain may cease, and the joint be anchylosed, or, what occasionally happens, it may become subluxated and otherwise distorted.[1] Rarely at this period is there much fluid effusion, but there is a sometimes leathery, sometimes more doughy thickening, filling up all the space between the skin and the bones, obscuring the proper shape of these latter, and giving a peculiar, unmistakable sensation to the hand. This and the history of the rheumatic fever immediately preceding, sufficiently mark the diagnosis of the disease. It may, however, be said that joints cured of such attacks may, after years of health, become affected with hydrarthrus.

But rheumatic joint disease is not always immediately due to the fever; it may originate, when the diathesis is present, in some exposure or slight traumatism, or in both. Under these circumstances the disease, more or less acute, may be continuous, but is often remittent, coming on irregularly at intervals—each attack leaving the joint lamer, and in a condition very prone to further disease. Even during the intermissions, the joint is not quite at ease; perhaps a mere stiffness on first rising will be for a time the only inconvenience, but afterwards will follow a certain discomfort in bed, a difficulty in finding a position in which the limb is at ease, and a sensation of half-developed cramp in some of the muscles.[2] If the diathesis be strongly marked, there are frequently also, at this period, vague and uncertain pains in other limbs. The joint is now a little swollen, with a certain amount of fluid effusion, and the tonic contraction of the muscles is a little lax; at the knee, for instance, the patella floats a little loosely. Movement, particularly after a period of rest, causes a crackling to be communicated to the hand, of a sort that reminds one of what is heard when sand gets between the teeth. Not unfrequently this crackling is quite audible—a coarse and rough, but not a hard grating. The patient may, after a time, recover, and perhaps permanently; but very often some imprudence in diet, some exposure or over-fatigue, or simply a loss of health, may bring on recurrences which occur again and again, till the patient is obliged to confess to himself that the joint is getting weaker and more painful.

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[1] I have now under my care a patient, aged 54, who has suffered a severe attack of acute rheumatism; her right wrist is fixed partly by fibrous anchylosis, partly by tendinous adhesions; her right knee was swollen, and very painful when I first saw it, and was suffering three forms of distortion—subluxation backward, abduction, and outward rotation of tibia.

[2] At the knee, the biceps is more particularly subject to this sort of pain, chiefly in the tendon where it bounds the popliteal space.

At this time the signs of diathetic influence are sufficiently marked. The patient is distressed, perhaps irritable, never quite free from pain. The temperature rises at night. The tongue is white, perhaps creamy, and marked at the edge by the impress of the teeth. The breath has a faint odor. The urine is very acid, depositing lithate of ammonium, or the red sand (uric acid). The joint itself is somewhat tender and hot, in some cases red; its movements of flexion, and more especially of extension, are limited and painful. Fluctuation, if it can be detected, is rather distant, there being evidently a solid thickening between the wave of fluid and the skin. If there have been but little fluid effusion, or if fluid, previously abundant, have disappeared, crackling is distinct. The shape of the swelling is very characteristic; it is not, especially when there is little excess of fluid, round, like the enlargement of either serous or strumous synovitis, but is angular or square; it is to palpation tough and leathery, and has somewhat abrupt edges; that is to say, in tracing with sufficient pressure the form of the limb from its middle downward, all is normal till the hand, arriving at the neighborhood of the joint, detects distinctly the abrupt edge of the hard, elastic swelling; this is very distinctly felt at the bursal prolongations. By this time the limb-segment above, and, to a less extent, that also below the joint, will have become considerably wasted.

The disease no longer intermits, although it may fluctuate. The muscles, which formerly were somewhat painful and tense, now begin to twitch at night, and those twitchings soon develop into regular starting pains, which often, in this disease, are extremely severe, and are not merely limited to the period of falling asleep. Occasionally a slight movement will bring them on, and at the same time a sort of spasm in the limb, which is very distressing, and which causes a sort of pain in the joint, as though it were being slowly forced asunder. The limb wastes very rapidly, and the cord-like muscles feel hard beneath the skin. Tenderness about the joint is slight, save at a spot a little inside the patella, which often will not bear even slight pressure; and here is the chief seat also of the pain. The heat about the part is considerable; redness is only observed in the earlier stages, but I have constantly observed, in older cases, a peculiar, dark, almost brown, appearance of the skin.

Abnormal mobility is in the late stages very frequent, and is often accompanied by a particularly harsh grating—a smooth but hard crepitus—and sometimes by severe pain and by spasmodic contraction of the flexors.

The more hydropic joint-rheumatism is at its commencement a milder affection, though, if not cured, its later stages lead to very considerable evil. It also begins with fluid effusion, which gives, as a rule, no pain further than a dull aching, with a sense of distension and weakness. If there be any pain at all, it comes on after prolonged exercise or over-fatigue. Perhaps, too, while using the limb, a sharp, quick pain, leaving for some minutes a considerable remnant, may occur. The joint is more rounded than in the other form of rheumatic synovitis. The positions of ligaments and tendons are less distinct than in acute sero-synovitis.[1] Palpation very readily detects fluctuation, which lies very near the hand. If the surgeon, with his finger-tip placed on the most accessible part of the synovial membrane, rub the soft parts with sufficient pressure to and fro, he will feel a peculiar crackling, and when the patient alternately bends and straightens the limb, the surgeon may with the palm detect a similar friction-sign. Both these forms of crepitation are very fine, especially the first. I have named it *silken crepitus*, because it is exactly like what may be obtained by rubbing between the finger and thumb two opposed surfaces of stout silk. At a later period, the crepitation, especially that produced by movement, becomes coarser; afterwards, if the joint get very full, both forms may disappear. But we have now to do merely with early symptoms, and I would direct especial attention to the fact, that, in a large proportion of cases, the surgeon's finger, rubbing the soft parts about the joint up and down, will feel, besides the crackling, a number of little lumps, gliding away under and escaping from the pressure. These are evidently very abundant, very movable, round, or rounded, and not hard. Cases presenting these symptoms will, if not cured, end in one of two ways—either as one of simple hydrops articuli, or as one of multiple false bodies with some little effusion. Both of these maladies are discussed in a subsequent portion of this article.

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[1] After a certain duration these parts are not designated at all. The joint, more especially in the case of the knee, assumes the shape of a ball.

TREATMENT OF RHEUMATIC SYNOVITIS.—If an inflamed joint, after acute rheumatism, comes out of the physician's care into the surgeon's hands, some malposture is very commonly found. In such a case, the severe fever has probably produced such suffering and restlessness that it has been hardly possible to keep the limb on a splint. Thus it is usually the surgeon's first duty to place the limb in a proper position, even though inflammatory symptoms be still pretty strongly marked. This alone, as in other joint-diseases, will very much mitigate the pain, and I have known it to cause the nightly high temperature, appearing at first sight as a remnant of the fever, but in reality due to the joint-inflammation, to decline. If the very slight force which nearly always suffices to place the limb upon a splint, in the proper posture, should produce pain, a small hypodermic injection of morphia near the joint will afford relief.

After this, the limb must be kept in one of the removable splints described in other sections. Blisters are, in my experience, more valuable in this form of synovitis than in any other joint-malady; they should be small, should be allowed to heal quickly, and should be frequently repeated: they[1] are most efficacious, in the case of the knee, when placed over the patellar plexus; and though other points of skin must of course be utilized, most of the blisters should be applied in patches about 1½ inches in diameter, over a hand-wide space above the patella and inside of the rectus tendon. Another remedy whereby counter-irritation, or indeed vesication, may be produced, is the oleate of mercury, first introduced by Mr. Marshall. It is made by rubbing up the yellow oxide of mercury with different proportions of oleic acid, so as to procure a compound of which the mineral salt forms either 5, 10, or 20 per cent.[2] The stronger preparation will blister most skins if painted on, night and morning, for a day or two; the weaker may be rubbed on with a piece of flannel. We may thus use either one or the other, according as we want a more or less irritant action. The value of this drug is difficult to fix. I certainly have seen cases in which sluggish, hard swelling rapidly diminished under its use; while in other cases, merely the ordinary effect of counter-irritation appeared to follow. A slower local action of mercury may be produced by using, under a compress, for several consecutive nights and days, equal parts of mercurial and iodide of potassium ointments; or, if gout be certainly absent, another part of iodide of lead ointment may be added. Iodide of cadmium is also much extolled, or the iodide of potassium ointment may be used alone. The judgment which I would give as to all these remedies, is that as adjuvants to other means they may be advantageously employed, as long as they are considered as mere aids; but that they should never be used as though they could be of the slightest use without careful mechanical treatment.

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[1] One method of treating acute rheumatism, which has been highly extolled, is by frequent blistering.

[2] The formulæ stand thus: yellow oxide of mercury, gr. v, gr. x, gr. xx, mixed with oleic acid, gr. xcv, gr. xc, gr. lxxx.

In the mean time, such remedies as are useful in rheumatism should be given internally; but the medicinal treatment will fall more naturally into our subject when discussing the remittent form of the disease.

While thus placed, the patient being at rest (in bed if the disease be in the lower limb), careful watch must be kept lest an unnecessary anchylosis, or considerable joint-stiffness, accrue. The ease and rapidity with which rheumatic disease leads to anchylosis must be borne in mind, as also the liability to adhesion of tendons to their sheaths, or to neighboring parts. While pain and tenderness at the special points[1] are present, absolute rest must doubtless be continued; but when these are absent, some change of position, not at first by passive movement, but merely by changing occasionally the angle of the splint, may advantageously be used, while note is taken concerning any increase of pain, or any rise of temperature.

When the inflammatory signs have ceased, or are but very slight, the malady comes into the same category, as far as treatment is concerned, as the slower and more remittent form to which in the description I have given the second place; that is to say, we have to do with a diathesis which marks itself by fits of exacerbation, alternating with intervals of apparently perfect health. It appears to me that such sequences can only be interpreted in one way. The system elaborates, or fails to excrete, or both, a certain constituent which, accumulating, brings on, after a time, these characteristic symptoms; by treatment or otherwise, this constituent (poison, if the word be preferred) is extruded from the body, and the symptoms then cease, leaving mere effects of the disease behind them; then the same sequence of events recurs. We have, therefore, to do with two phases of the malady, the active and the preparatory. In the active stage, the treatment must be very much guided by the condition of the urine and other excreta. In some patients the bowels and liver are evidently much in fault; the alvine evacuations are scanty, and sometimes clay-colored, a condition in which a mercurial purge or alterative, according to the more or less robust powers of the patient, is useful; or if it be designed to use mercury locally, podophyllin or leptandrin may be substituted. But the great guide to medication must be the condition of the urine, and the amount of pyrexia. If the excretion be highly acid, and if it deposit the lithate of ammonium in large quantities, bicarbonate and nitrate of potassium and ammonium are indicated, and, when pyrexia is superadded, these may be administered also as febrifuge remedies; thus of carbonate of ammonium, twenty-five grains, in a fluidounce of water, may be given in an effervescent form with citric acid, twenty grains, in a similar solution; to this may be added, when the fever declines, the wine of colchicum or the iodide of potassium, or both. Or again, if the fever be high, salicylic acid, or the salicylate of sodium may be employed. In the mean time, butchers' meat must be cut off, and, in most cases, all stimulants also; but if this be undesirable, the safest form of stimulus is old and pure whiskey, in a large quantity of water.

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[1] See page 310.

Of wines, hock and claret are the least harmful; next to them, still and sound Moselle. The treatment during the intervals is not the least important, its object being to prevent the storing up of the *materies morbi.* This, though hardly feasible in inveterate cases, inherited perhaps through several generations, is far less difficult in a condition acquired by wrong habits of life. Rapid feeding on badly masticated food, excess of stimuli, especially of beer or of sherry, sedentary habits, and study, undertaken immediately after meals, all tend to this condition; and probably more important than the exhibition of any drug, is the rational regulation of the patient's life. For medicines, when the urine is acid and loaded with lithic acid or lithate of ammonium, the potassium neutral salts, and iodide of potassium or ammonium, will be found useful, while some of the saline waters, as those of Vichy, Carlsbad, Kreuznach, and often the Woodhall Spa of Lincolnshire, may be advantageous. Sulphurous waters, as baths, are in some cases very useful, and certain patients have found benefit from baths of artificially sulphurated water. These are easily prepared by pouring over an ounce of sulphur, broken rather small but not powdered, a pint of boiling water, and, after this has stood five minutes, pouring the whole into a bath previously raised to the temperature of from 93° to 97° Fahr. The patient should remain in the bath a quarter of an hour, additional hot water being added if desirable.

There is, however, another form of rheumatism, which is very obstinate, and usually very painful. It is combined with pallor, anæmia, and an alkaline condition of urine, or one which at least tends to alkalinity. In such cases the treatment must be in almost every particular the reverse of that above described. Alkalies, or the neutral vegetable salts, are injurious; while quinine, iron, salicylic acid, and a certain amount of wine—even sometimes champagne or port wine—are beneficial, at least for a certain period. This condition may have been caused by too assiduous and long-continued treatment of the more sthenic form, or may simply be due to rheumatism, combined with the depressing effect of little food, bad air, and over-work. The appearance of phosphates in the urine must be treated on the usual principles of relieving that condition.

In the mean time, as soon as the more pressing symptoms of joint-inflammation have subsided, passive movement and shampooing have great effect in causing the absorption of the deposited fibrine. The friction should be especially directed centrifugally, the object being to induce activity of the absorbents.[1] In carrying out these measures, the tendency to adhesion of tendons to their sheaths must not be forgotten, and the friction must be directed also to those parts. If the disease be of the wrist, each finger and the thumb should be separately moved; or, if of a compound joint, like the elbow, each of the movements—flexion, extension, supination, and pronation—must be attended to. If the acuter stages have passed, and have only produced slight stiffness, the case is very hopeful; but if considerable stiffness be left, the prognosis is less favorable.

Gouty Synovitis.

Gout is a malady of very protean character and of very variable severity; nor are the troubles which it produces by any means confined to the joints. Its essence, more demonstrable than that of most other diseases, is a blood surcharged with uric acid, which, combined with soda, forms, when dry, a pulverulent, when wet, a pultaceous substance, that from mere excess infiltrates various tissues of the body, and among them those of the joints, and preferably the smaller joints. The pathology of the disease, as thus broadly stated, is attractively simple. We have, on one side, the evidence of a redundant material in the blood, which we can crystallize out upon a linen or cotton thread;[1] on the other, we have a thread or fibre of the human body, on which the crystals form. But it is not to be assumed that herewith all that is worth knowing has been learned; many points remain to be elucidated, and more especially of interest to us are the causes of this great accumulation in the blood of the *materies morbi*, for the accumulation may come from excessive production, from deficient excretion, or from both.

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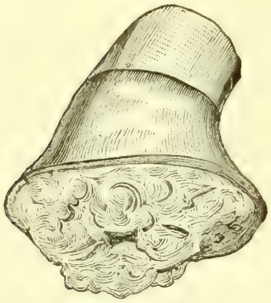
[1] See p. 322.

Gout is an hereditary disease,[2] which only exceptionally attacks young people, but usually manifests itself in the descendant, son or grandson, at about the same age as it appeared in the progenitor. It is much more common among men than among women,[3] a fact which, although partly due to difference of habits, is not entirely so, since many men, quite as abstemious as women, are subject to the disease. Gout, or tendency to gout, is greatly promoted by a largely nitrogenous diet, and by fermented liquors—especially by such as contain, with the alcohol, a large quantity of grape-sugar. Persons who are exposed to the influence of lead are peculiarly liable to be attacked by gout; and conversely, gouty persons are extremely sensitive to the influence of lead.[4] There are several forms in which gout may be manifested: by an acute fit, by chronic disease, and by irregular manifestations (non-articular gout), which may affect any structure of the body. All these may be either tonic or atonic.

The early fits of gout attack healthy structures, through which blood containing abnormal quantities of uric acid is circulating. The disease commences nearly always in one of the small joints, and as a very general rule in the first joint of the great toe,[5] by inflammation of an acute kind, during which the fluid poured into the joint, and that forming the rather considerable œdema, are rendered milky, or rather like chalk and water, by the great admixture of lithate of sodium, whose grittiness may be felt if the liquid be rubbed between the finger and thumb. After a time, when the inflammatory effusion subsides, the lithate is left, either as a half-dry powder or as pasty masses, in the cavities and among the tissues. These masses, when they attain such a size as to be appreciable from the surface, are commonly called chalkstones or tophi. Owing to the extreme opacity of this substance, it is very difficult to make out its precise histological position. Some of it is, evidently, merely deposited mechanically, wherever a cavity has been filled with the surcharged fluid. Other, generally smaller, portions appear more regularly placed, grouped chiefly around the cells of such structures as cartilage, tendon, or ligament, all of which are frequently the seat of this deposit, as is less often the bone in the

Fig. 643.



Terminal phalanx of great toe; cartilage thickly infiltrated with urate of sodium. (From a preparation in the Museum of the Charing-Cross Hospital.)

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[1] Garrod, Treatise on Gout, etc., 3d edition, p. 87.

[2] About 8 cases in every 10 are hereditary.

[3] About 2 of every 100 cases are in women.

[4] I once saw a gentleman who was very gouty, and on whom an ointment containing a very little lead had produced poisonous effects, giving him the blue line on the gums.

[5] Probably two causes for this preference exist: the distance from the circulating centre and the pressure of the long blood-column, and the considerable stress brought to bear on this joint by the weight of the body. Gouty persons are often obliged to be careful as to their amount of walking, excess beyond a certain distance bringing on an attack of the disease.

immediate neighborhood of the affected joints. It is to be remarked that the deposit has but little affinity towards organs or parts of organs which are very vascular. Thus the cartilages and ligaments are first and most frequently affected; the synovial membrane itself is less often spotted with chalk-stone, and, when it is so, the fringes are very usually spared.

After a time, or in some persons from the very beginning, tophaceous deposits, accompanied by inflammatory phenomena, takes place also in other organs; for instance, very commonly in the pinna and in the subconjunctival tissue of the lower eyelid, where they appear as little white beads, or in bursæ, both deep and subcutaneous. But far more important are the very frequent and grave changes that take place in the kidneys. These occur very early; and it may even be argued that the true cause of gout lies in a functional derangement of those organs, which interferes with the excretion of uric acid. This derangement will be more fully described hereafter, but just now we are only concerned with the anatomical changes. A section of the kidneys shows, in the medullary portion, fine white streaks converging towards the hilus. These consist of deposits of urate of sodium, at first probably in the interior of the tubules, but afterwards between the tubules and extending into the cortical substance, and in advanced cases even to the surface, so as to be visible beneath the capsule. This deposit gradually induces a form of Bright's disease known as the granular contracted kidney, which is accompanied by albuminuria.

Furthermore, we have to consider certain affections not as yet shown to result from the physical deposition of urate of sodium, but certainly due to its presence: such are skin-eruptions—eczema, psoriasis, urticaria, and sometimes erythema—as also peculiar and very possibly similar states of the surface of mucous membranes, causing catarrhal enteritis or gastritis, or a more severe form of intestinal inflammation. Some gouty persons, moreover, are troubled with a peculiar form of chronic bronchitis, culminating occasionally in acute attacks, and leading to stenosis of the smaller bronchi and to emphysema. Another grave lesion is a form of atheroma, with fibrosis of the capillaries, both producing vascular rigidity and tendency to rupture; hence, apoplexy not unfrequently terminates a gouty life. Other functional derangements appear related to the morbid condition of blood, rather as cause than as effect; these are, besides the disturbance in the execretory function of the kidney, above alluded to, a certain turgid and congested condition of the portal system, which gives rise to considerable derangement of digestion, with formation of much acid in the stomach and intestines, sour eructations, and the passage of flatus, together with a depressed and very irritable state of the nervous system.

Mention has been made of deficient excretory power of the kidney. This more especially refers to the elimination of uric acid. It is one of the earliest manifestations, perhaps, with portal congestion, the very earliest manifestation of gout. A healthy man of 150 lbs. weight, should excrete on an average about 8 grains of uric acid, and 620 grains of urea, in the twenty-four hours.[1] Now, in the early stage of gout, that is, some weeks before the first attack, the amount of the former excretion is very much diminished, that of the latter not at all, or hardly at all, affected; afterwards, only slight traces of uric acid, or none, are eliminated, and the excretion of urea is also much diminished, while some albumen begins to show itself in the urine.[2]

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[1] The average amount of urea may be taken at 1 drachm per stone (14 lbs.) of body weight in the twenty-four hours, that of uric acid at from 0.5 to 0.75 grain per stone in the same period: but both these constituents of urine, more especially uric acid, vary very much, according to the exercise taken, and the more or less nitrogenous quality of the ingesta.

[2] For these peculiarities of the urine, see Garrod, op. cit.; Lehmann, Phys. Chemie; and Bartel, Symptomatologie der Nierenkranheiten.

Hence, it may be surmised (not concluded) that the *causa morbi* lies in a certain vice of the nutrient functions, including the dissolution and removal of effete tissues, whereby uric acid is formed in superabundance, or is not converted by further chemical changes into some more easily eliminated material; and that the blood thus surcharged acts injuriously on the kidneys, retarding or preventing the secretion of the substance in question so as to still further increase the saturation of the blood, and ultimately rendering those organs not merely functionally, but organically diseased.

SYMPTOMS.—The form of gout with which only we have to do here is the articular.[1] It has several varieties: acute, sthenic gout, commonly called a fit of the gout; asthenic gout, the fits of which are more commonly subacute; chronic gout, which commonly means the condition left by the acute fit, added to a certain amount of inflammation, and occasionally varied by an acute attack; and simple goutiness, viz., a more or less crippled, non-inflammatory condition of the parts in which the deposit has taken place. It is unusual that a patient should, without having had at least one acute attack, suffer from articular gout and chalk-stone deposit.

The first fit of *sthenic gout* may be taken in practice as the starting-point of the disease; although, from what has been said, it is evident that for a considerable period previous, the excess of uric acid in the system has been preparing. The patient may feel and seem to others to be in good, and even in uncommonly good health, taking food with unusual relish, and perhaps in unusual quantity; or it may be that a certain irritability of temper is observed; or again, he may be unwontedly disposed to fall asleep after dinner—the bowels being at the time a little constipated. Some night, after falling asleep with ease and readiness, he wakes about two or three o'clock with pain in the ball of the great toe; a sense of heat and bursting that in a little time becomes intolerable. On examination, the part is found to be of a deep red, with sometimes a tinge of purple, in which full turgid veins are strongly marked. Œdema causes considerable swelling, and is often more extensive than the redness; the skin is tense and shiny. The toe and its surroundings are extremely tender. As daylight comes on, the pain and the objective signs begin to diminish, and, perhaps, during the day may so far disappear that the patient thinks he has escaped with the fright; even though some pain return in the evening, he may, if still a novice, go to bed with happy assurance; but scarcely has he shaken himself into place before a sharp throb tells him that the enemy is upon him, and forebodes another night of what amounts to torture; and so on through a succession of nights until the fit passes, again, however, to recur at intervals of from four to six months. Each of these fits is accompanied by a certain degree of pyrexia, the rise of thermometer preceding, according to my observation, the pain; the skin is hot and dry; the urine very scanty and high colored. After the attack, all the part that has been inflamed desquamates, not in small furfuraceous scales, but in large flakes.

The early attacks, unless unusually prolonged and severe, leave but little local mischief behind them; but each succeeding one produces more and more injury, and the intervals, therefore, are less free. As a compensation, a joint which has been attacked once or twice, is less painful during the fit than it was at first; other joints are, however, liable to become affected.

Asthenic gout is, if we take typical cases of each form of the disease, very different from that above pictured; the attack is both less sudden and less severe, the patient feeling a gradually increasing pain, which is never violent; the redness may be a mere blush; the veins are hardly turgid, and the œdema, if any, is slight and deep; pyrexia is hardly marked; but the patient is much depressed in spirit, and low in health.[1] Unfortunately, these attacks are followed by greater injury to the part, and the intervals are less free, than in the other form; other and larger joints also become more speedily involved.

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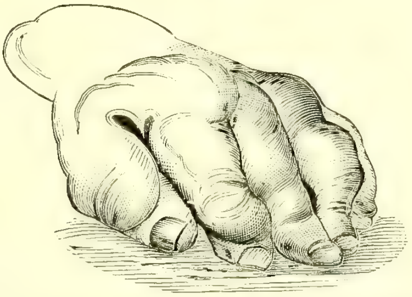
[1] It is nevertheless essential for the surgeon to know that gout may attack other, especially internal, organs, when the disease may become exceedingly dangerous. If this occur alone, and without simultaneous or immediately preceding joint-affection, it is termed misplaced, aberrant, or non-articular gout; if it arise during an attack of articular gout, which then subsides—a species of metastasis—it is called retrocedent gout.

Chronic gout is the condition which exists during the intervals between the fits. In these intervals, the patient is, in different cases and in the various stages of the disease, more or less relieved; but it is only after the first fit or two of sthenic gout that he feels quite free from the malady. After many attacks, more or less trouble is continuous. When a certain amount of deposit has taken place, its presence always keeps up a certain degree of pain and a certain amount of inflammation, which augments the injury already done. In a few instances, chiefly of asthenic gout, this state continues uninterruptedly; most persons, however, suffer from periodical exacerbations; and during intervals of either comparative quiescence or moderated fit, fresh joints, tendinous sheaths, or bursæ, may become involved; also, and this is of especial importance, it is during this sort of diseased action that gouty degenerations, such as are found in the vascular coats, chiefly occur.

After several fits of gout, or after a considerable period of the more quiet form of suffering, great accumulations of chalk-stone are found, as well in the joints as in the sheaths and bursæ. I have seen the end of the first metatarsal bone, and the corresponding part of the phalanx of the great toe, so completely occupied that they seemed converted into urate of sodium, with sparse trabeculæ of osseous matter running through them; and the sheaths of tendons, both at the ankle and wrist, with the bursæ over the olecranon processes, and several others, merely bags of chalk-stone. Both hands were grotesquely padded and swollen, with irregular lumps, so that they looked like bunches of badly grown horse-radish.

Fig. 644.



Hand beset with urate-of-sodium deposits. From a preparation in the Museum of the Charing-Cross Hospital.

Attacks of misplaced or of metastatic gout are dangerous according to the vital importance of the organ involved; they frequently observe, in both the acute and chronic forms, a sort of alternation with the joint affection—while the one is severe, the other will be slight, and *vice versa;* the non-articular form is sometimes called "suppressed." These internal affections interest us only in a secondary manner.[2] I need only mention gouty encephalitis and cephalalgia, sometimes delirium, and rarely mania, cardialgia and angina, syncope, bronchitis and asthma, gastritis, gastralgia and enteritis, as also the affections of the skin already named, to show (and there are several others) how many and how varied may be the maladies produced.

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[1] Sometimes it is difficult to diagnose these cases; considerable help may be obtained by observing the subsequent desquamation, which very usually follows, but not so constantly as after a sthenic attack.

[2] They are only mentioned here, since certain modes of treating articular gout occasionally produce retrocession.

TREATMENT.—The treatment of gout must vary according to its stage, whether acute or chronic, and both forms of treatment must be modified according to the more sthenic or more debilitated condition of the patient. A fit of acute, sthenic gout, especially if such attacks have not frequently recurred, may be treated with a saline purgative, combined with twenty or thirty minims of the wine of colchicum, or, if the skin show any icteroid tinge, the draught may be preceded for two hours by a mercurial, such as gray powder, blue pill, or even calomel, if the discoloration be well marked and the bodily power considerable. It not unfrequently happens that just before being seen, the patient, previously suffering comparatively slight and vague pains, will have eaten a full meal, after which the attack may have culminated. In such a case, the safest and most efficacious remedy is an immediate emetic of potassio-tartrate of antimony and ipecacuanha wine, followed, when the stomach has sufficiently reposed, by a smaller dose of the purgative. At this time, at all events, opiates should be avoided, as they diminish the action of the kidneys; but if the pain be violent, a small dose of the compound ipecacuanha powder may be given, or a quarter of a grain of morphia may be injected under the skin. I have, however, often found that

Potassii bromidi . . . . gr. xx.
Liq. atropiæ salycilatis . . . . ♏ x.

acts as an excellent anodyne, procures sleep, and enables us to avoid the evils of opium or its alkaloid.[1] Chloral, though valuable in mere restlessness, is powerless against pain. When the fever is high, and the local inflammation considerable, the tincture of aconite, in the dose of one minim every hour or every two hours, has often, in my hands, proved very beneficial. In less severe cases so powerful a drug may be avoided. By the patient's side, or in charge of his attendant, should be left some doses of the effervescing citrate of potassium, of which, with plenty of water, he may drink freely during the night; it will not merely slake thirst, but will act on the kidneys and on the skin.

For the next few days somewhat similar treatment must be continued; colchicum should as much as possible be spared, since it certainly has a tendency to provoke or hasten recurrence; yet when the pain is violent and of a peculiar "bursting" character, it may be impossible to avoid its use altogether; ten minims twice during the day, and at bedtime, unless violent pain recur, when the last dose may be doubled, should fully suffice. It may be given with the effervescing citrate of potassium, with bicarbonate of potassium, or if one have faith in them, with the preparations of lithium. The bowels should be kept freely open with salines, and plenty of fluid should be taken.

In the mean time food must be limited almost entirely to bread-stuffs and milk; all wines and beer must be strictly forbidden, but if digestion will not go on comfortably without some stimulant, a little old whiskey in some effervescing water may be allowed. In a few days more, when the urgency of the attack and the fever are abating, or from the first if the patient be feeble, some light fish may be added to this diet.

The *local treatment* during this time must be guided by the sthenic or asthenic condition of the patient, and by the amount of inflammation. With some very strong persons much relief is obtained by the application of from two to four leeches over the inflamed joint. In feebler persons, a blister about the size of a shilling, is more efficacious; it withdraws with the serum a good deal of the urate of sodium. The part should be kept warm: cold, though it often for the time may seem grateful, prolongs and aggravates the attack, and may even be dangerous by causing the inflammation to recede to some internal organ (retrocedent gout). Therefore the part should be wrapped in light cloths, wrung out of a hot solution of bicarbonate of potassium (gr. x–f℥j), to which may be added some extract of belladonna or tincture of opium. Or absorbent cotton-wool, into which some strong spirit of camphor has been shaken, may cover the part, and generally the tenderness is such that the weight of the bedclothes must be supported on a bed-cradle.

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[1] The liquor atropiæ salicylatis is thus made: Take of atropia 5 grains, and of salicylic acid 7½ grains, rub the atropia to a very fine powder, and then little by little rub with it the salicylic acid. Add slowly 10 fluidounces of hot, distilled water. The whole must dissolve, and the solution must measure, or be filled up to, ten fluidounces.

The treament of gout in the *intervals of attack* must depend on its sthenic or asthenic quality. In the former variety, food and drink must be limited, and especially the nitrogenous elements kept very low; stimulants, as far as possible, should be avoided, or, if some must be given, it should be old, pure whiskey, or gin, largely diluted. The kidneys should be encouraged to free action, but not stimulated—an indication which I have found best fulfilled by digitalis; the action of the skin also must be aided—an occasional hot-air bath is often useful. Of great importance is proper regulation of the bowels and liver; this, no doubt, may be effected by colchicum in proper combination; but, as pointed out a short time ago, the drug has certain disadvantages. Some practitioners give a hydragogue cathartic every morning, and with certain strong constitutions this may be advantageous; but it does not prevent the tendency to portal congestion. I have found the resin of podophyllum, in $\frac{1}{10}$ grain doses, very useful for this purpose.[1] If more purgation be desirable, the saline purge can still be given occasionally before breakfast. The patient should be encouraged to drink freely of alkaline waters, which are most easily taken in their effervescent forms.

Atonic gout is more difficult of management, and must be more closely watched, as the possibility of lead poisoning, or of serious renal disease, must not be overlooked, while at the same time aberrant forms of the malady are more common in this than in sthenic gout. The treatment may be more tonic; a full diet, and a certain amount of claret or of hock may be allowed: the vegetable bitters, bark, or quinine, and even the lighter forms of iron may be given. With these, some bicarbonate of potassium or ammonium, or the iodide of potassium may be combined, especially if lead poisoning be suspected. But in the meanwhile the sufficiency of the excreta must be maintained. Ash-leaf tea, so highly recommended by certain writers, is both a bitter and a diuretic, but is void of any specific or very potent action in gout.

Certain natural alkaline waters and baths are frequently very valuable in either form of gout. Vichy, Aix-la-Chapelle, Baden-baden (especially the lithia spring), and Carlsbad waters are probably most useful in sthenic, but may, if used only for a short time, also benefit asthenic gout. Afterwards, a stay at some of the more slightly charged springs, such as Wildbad, Töplitz, Gastein, Bath, or Buxton, will probably be desirable. In the atonic form it will generally be desirable to begin with these latter, and to end with any of the lighter ferruginous spas—Schwalbach Spa, Tunbridge Wells, etc. The stronger springs of the Pyrenees are only suitable to cases of very marked debility.

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[1] The formula which I employ is this: Podophylli res. gr. j; Tinct. zingiberis, fʒij; Spt. vini rectificat. f℥j. A teaspoonful in water, twice or thrice a day.

Hydrops Articuli, Hydrarthrus, or Hydrarthrosis.

The names above given are derived simply from a symptom which accompanies several forms of malady, and therefore these terms include more than one kind of disease. We have to do with an increased effusion into the joint, which (1) originates in a demonstrable inflammatory attack; (2) begins without demonstrable inflammation and continues without further change than the thickening caused by the presence of the fluid; or (3) is accompanied or caused by great hypertrophy of the fringes (rheumatic hydrarthrosis).

Many cases of joint-dropsy follow immediately, others more remotely, after acute synovitis; and in some of these cases there is strong reason to believe that a fibrinous concretion, left behind, has become adherent to some point of the synovial membrane. Clinically, this idea may be confirmed by observing, in the early part of the case, that the patient refers a frequent and sharp pain to a certain spot which is not commonly the seat of such sensation.[1] Of course, however, in many of these cases there is no sign, no reason to suspect the presence of such a body. The inflammation, whether it have been more or less antecedent, appears to have changed the secreting or the absorbing functions of the synovial membrane, producing a congestion, often extremely well-marked after death, either general or in patches; the latter, I believe, more usual, except in old cases. Mere congestion, produced by venous obstruction higher up the limb, never produces hydrarthrus. Passive œdema, either as in general anasarca, or as that caused by pressure on the femoral vein from aneurism, spares the joints. Even though the limb be swollen almost to the point of bursting, no excess of fluid occupies the synovial cavity.

Pathological Anatomy.—I have had the opportunity of making examinations in several cases of this affection: one after fifteen months during which the lad had been quiescent, the case having begun in an acute synovitis, and others after four and more than seven years of chronic disease respectively; in both cases, of course, an abnormal amount of fluid was found in the joint. Besides this, there was in the former considerable redness of the whole synovial membrane, very marked in the folds on each side of the patella; but in one point of the subcrural sac was a spot of extreme hyperæmia. The fringes, especially round the patella, were a little more evident than usual; and hanging by a narrow stalk from the crucial ligaments, was a little hygroma. The cartilages were milky, sodden, and a little soft. I look upon the patch of excessive congestion in the subcrural prolongation as having been probably the cause of the hypersecretion, and upon the other changes as secondary.

In examining the other cases, which from the first were chronic and non-inflammatory, I found a remarkable condition of synovial membrane. The fluid in the joints was very yellow, albuminous, lubricating, but not thready. The cut edge of the synovial membrane exhibited a yellow pulp not unlike that of an over-ripe orange; in the older case this was, where most developed, 1½ inch, and in the more recent ¾ inch thick. It was soaked in, and possibly derived its color from, a similar fluid to that in the cavity; in its substance were a great number of little chambers communicating freely with one another, and varying from a microscopic size to such as would contain a No. 4 shot. The inner surface was composed of rounded or conical eminences projecting from $\frac{1}{8}$ to $\frac{1}{4}$ inch, with about similar diameter, and placed close together. This mass was surrounded by a dense bluish-white capsule, looking like condensed fascia or tendon; it was thicker in some parts than in others, averaging $\frac{1}{3}$ inch. There were no external ligaments save this capsule; the crucial ligaments were much elongated and loose; the cartilages, nowhere ulcerated, were fibrous almost throughout.

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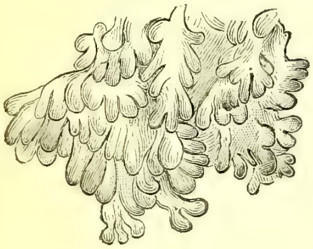
[1] It would seem that such a concretion, either by exercising a certain traction on the point of attachment, or otherwise, may produce a congestion or distension of vessels favorable to the effusion of much fluid. A mere soft, lipomatous, false body will have the same effect, the disease proving incurable till the growth is removed.

Microscopically, the pulpy mass consisted of a wide-meshed areolar tissue, composed almost entirely of yellow elements. The loculi were partially lined by endothelial cells. In one case there was no appearance of a hypertrophied fringe; in the other there were two, not dendritic, but formed of lumps about the size of horse-beans, pedunculated and attached to the synovial membrane by thin stalks.

We are thus forced to the conclusion that mere passive congestion from venous obstruction does not produce hydrarthrus—that, in other words, it is not, properly speaking, a dropsy—but that a capillary, active hyperæmia is the efficient cause; that in cases following acute sero-synovitis, this vascular condition is probably localized in one or more spots of the synovial membrane; while, when the disease is from the commencement chronic and non-inflammatory, the hyperæmia is more general, and tends, together with the effect of soakage, to a peculiar hypertrophy of endothelium, and of the immediately subjacent layer of the tissue—of the synovial *intima*.

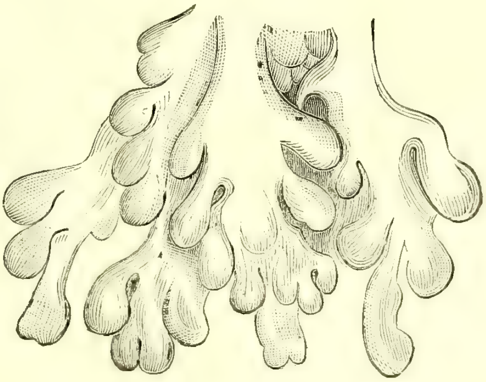
But a different condition obtains when the local malady, commencing or not after an acute synovitis, is mingled with the influence of a rheumatic diathesis, sufficiently strongly marked. In such cases the hyperæmia exercises its more strongly formative power in the production of very greatly hypertrophied fringes. These organs, developed for the purpose of increasing the surface for secretion, have, in this disease, their function exaggerated, with the effect of producing excessive secretion. In the beginning, the malady is a chronic rheumatic synovitis (page 322), but it more or less rapidly assumes activity both of secretion and of fringe-growth, and certain cases of that disease become the most obstinate examples of hydrarthrus. In this variety, the synovial membrane is chiefly remarkable for the shaggy condition of its internal surface, which looks as though covered with lichen, or which may be compared to the outer surface of the fœtal chorion. The villi,

Fig. 645.



Excessive fringe-growth of hydrarthrosis.

Fig. 646.



The same, under a powerful single lens.

as the hypertrophied fringes have now become, are variously formed and constituted in different cases. They are branched and ramified in all directions; but in some instances the twigs end in simple blunt points, in others they are bulbous, and in others beaded, giving the fringe a form like a bunch of currants. The bulbs or beads may be simply bags of fluid, or collections of fat, fibrous tissue, fibro-cartilage, true cartilage, or bone. The fringes, not remarkably vascular, contain each an artery and vein; the twigs are without such vessels, or possess only short branches, which terminate long before reaching their ends.

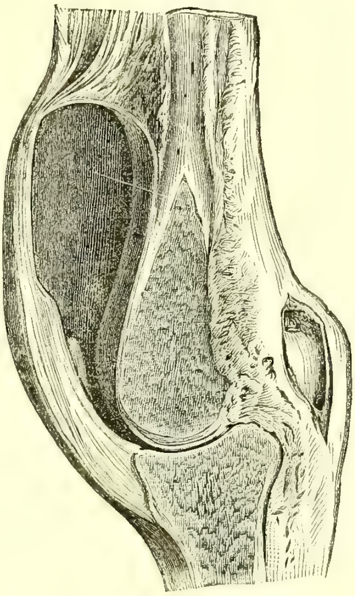
Occasionally, in such cases, the fluid contains a variable, sometimes an immense number of free concretions—the hydatiform bodies of Dupuytren; they are gelatiniform, yellow, and transparent, and, if numerous, very small—about the size of a pin's head or less. If only few in number, they are generally much larger.

The synovial and perisynovial tissues, thickened, soft, and sodden, are surrounded by a tough, firm capsule, developed in consequence of the pressure from within. In old cases this is sometimes so firm that even after withdrawing the fluid, in anatomical examination, the empty sac does not collapse. Moreover, this tendon-like capsule may be in places distinctly cartilaginous, plates of cartilage having been developed in the fibrous substance, or almost the whole tissue having undergone such a metamorphosis.

This latter form of disease is evidently related to cases of multiple false bodies in the joint-sac, and thereby to arthritis deformans; and we shall hereafter perceive that it is impossible to draw any sharp line of distinction to mark a point where the one malady may cease, or the other may begin. In many cases of hydrarthrus, after the fluid has been withdrawn, a number of these bodies may be felt; and again, in certain cases of single loose cartilage, the accompanying hypersecretion ceases after removal of the loose body.

Symptoms.—Hydrarthrus rarely affects youth, and is more common after than before forty-five years of age. Its history may be either that of a gradual, painless increase of size, or it may have begun with an injury, followed by acute synovitis, and by more or less painful sequelæ. The histories being thus dissimilar, are of little aid to diagnosis, which, however, presents but slight difficulty, the essential feature of the disease being a large fluid effusion in the articular cavity, without any sign of inflammation, or at least of active inflammation. The signs and symptoms of fluid in the different joint-cavities have already been detailed (p. 267); but the greater quantity of fluid and its slow accumulation permit of more distension of opposing parts, and thus the locality of ligaments, tendons, etc., is little marked, while certain portions enlarge to an incommensurate degree. Thus at the *knee* (the most common site of this disease), the subcrural portion of the sac is more particularly distended; this is most visible when the patient stands erect. There is also considerable enlargement on each side of the patellar tendon. The synovial membrane, too, often bulges into the popliteal space, which then is no longer hollow, but prominent. Very often, at the *elbow*, the membrane is protruded through one of the openings in the posterior ligament, forming a bursa-like enlargement, usually in the immediate vicinity of a condyle. The chief swelling is about the inner condyle, where the fluid in many cases produces a large ovoid protuberance; the part of the sac that underlies the triceps is also considerably enlarged. Hydrarthrus of the *shoulder* has been observed by M. Roux and by myself. In my case the patient had almost lost the power of lifting the arm from the side; it measured, as it hung, half an inch more than its fellow; by lifting the limb sharply upward from the elbow, one could feel the head of the humerus impinge against the glenoid cavity, and the arm lost its abnormal length. The swelling was very peculiar; the cavity of the axilla was nearly filled up. The deltoid portion of the shoulder was very large, more especially at the anterior and posterior part. Behind, the fluid tumefaction occupied the outer half of the infra-spinous fossa. On the top of the swelling the acromion seemed to form a depression, more especially visible when the arm was pushed upward, as above described. Of course, in all these cases fluctuation from one part of the tumor to the other is very distinct. When distension from within, by fluid accumulation, has gone on for a considerable period, the ligaments and other fibrous tissues about the joint become considerably lengthened; they no longer bind the bones firmly together, and the use of the limb is much impaired; the tibia or ulna may in such cases be rotated, abducted and adducted, or made to glide sideways on the femur and humerus respectively.

Fig. 647.



Simple hydrarthrus of knee; distension of subcrural sac; bursiform enlargement laid open behind.

Diagnosis and Prognosis.—The mere detection of a non-inflammatory accumulation of fluid in the joint, easy as it is, gives us the diagnosis of hydrarthrus; but in order to form a probable prognosis, we must distinguish the one sort of case from the other. While distension of the joint-sac is still moderate, we may, by pressing deeply on its most accessible part, obtain, if there be fringe-hypertrophy, that gentle, soft crepitation which I have described as "silken crepitus," which will be of finer or coarser quality according to the smaller or larger size of the growths. Sometimes, in verifying fluctuation, the hand will feel, as the wave passes from place to place, a sense of the movement, the actual current; this cannot of course be due to the motion of a pure fluid; it is caused by the passage under the fingers of those little semi-solids already mentioned (melon-seed bodies). But when the sac is completely full, these peculiarities cannot be felt until it be partially or entirely emptied. In the latter condition, we may also detect any nodular terminations to the fringes that may be present. Also, but best when the joint is half empty, any plates of cartilage or other substance developed in the joint-tissues can be made out; they are to be felt as harder portions floating on the subjacent fluid, and slightly elevated beyond the surrounding structures; they can be depressed towards the cavity, but cannot be moved from side to side, and cannot be so isolated as to be grasped in the fingers.

The prognosis depends very much on the presence or absence of fringes, nodules, and extra-articular plates; it is unfavorable when the two latter can be felt, but is less bad when only fine fringe-hypertrophy is present. When no sign of internal roughness or of plates can be felt, the prognosis, though guarded, may be fairly favorable, unless the disease be old, abnormal mobility free, or the constitution broken either by age or marked diathesis.

TREATMENT.—Unless very unmistakable signs of vicious diathesis be present, any systemic treatment of hydrarthrus is nugatory; no amount of purging or diuresis will, in any appreciable degree, affect the disease. Rest in bed often has a marked effect in reducing the swelling, especially if the case be recent, and if the patient has previously been freely walking about. In all cases, especially if pain exist, the limb should be splinted. Also, in recent attacks, pressure, by means of an elastic-webbing bandage, is beneficial, and may even be curative; the parts below must be supported by a firm linen or cotton bandage, to prevent swelling. Iodide of potassium or of lead may be applied under the bandage, and I believe myself to have seen good effects from such treatment. It must always be remembered that these milder methods may appear while the patient remains in bed to have been perfectly successful; but the surgeon must be careful not to encourage false hopes, for it not unfrequently happens that as soon as movement recommences the disease returns.

Evacuation by puncture or aspiration is a most valuable resource. Care must be taken to avoid the entrance of air, as already described (see page 274.) As soon as all the fluid has been drawn off, an elastic-webbing band should be firmly applied, the limb being supported on a splint. In more than one case —notably that of a medical man, who had been for five years almost incapacitated from going about—I have succeeded in curing the disease by these simple means. Sometimes it happens that the fluid will not flow through the fine canula used for evacuation, but sometimes, in spite of such failure, the subsequent pressure has been quite successful; I suppose because the fluid has been slowly squeezed out into the surrounding tissues. If this result do not occur, or even at once, when no flow takes place, a tenotome may be passed into the same opening, and a large incision made beneath the skin in the synovial membrane. If the tumefaction be great, this may be practised on both sides of the joint, and afterwards the pressure applied; in doing which it is well to endeavor to get one edge of the divided synovial membrane to overlap the other.

If evacuation through the trocar have been practised with temporary success, but with subsequent recurrence of the disease, injection of some irritant substance may be employed. The best of these is doubtless iodine; one or even two fluidrachms of the tincture of iodine in the fluidounce of distilled water may be employed. The fluid from the joint should be measured, and, all appurtenances being at hand, a like amount of the solution should be mixed, and at once gently injected through the canula; a little force may, towards the termination of the injection, be used to induce the full quantity of fluid to enter, but sometimes this is impossible. When the injection is completed, the joint may be gently kneaded (the canula being occluded), and the limb raised and turned on the side, but without moving the joint, to insure, as far as possible, contact of the liquid with all parts of the cavity. As soon as a certain sense of heat in the part, together with a dull aching up the limb, is experienced, the canula-mouth should be opened and the solution allowed to flow; it should then be gently pressed out of the cavity, either by the hand or, better still, by an elastic bandage.

Free incision appears a very heroic method, but by proper precautions, using either carbolic acid or boro-glyceride, is in reality very safe, and is no doubt exceedingly efficacious, especially when fringe-hypertrophy or melon-seed bodies exist. But the incision must be really free, not a mere little cut. If it have been made over a place where the silken crepitus gives evidence of fringe-hypertrophy, one or more of the growths will probably float out, and may be removed, which is best done by twisting. I have on more than one occasion passed my finger into the joint, brought enlarged fringes to the surface, and removed them. Afterwards, a tube is passed just within the cavity, and a strong stream of some aseptic fluid injected. I think carbolic acid is best for this purpose, as its stimulating effect is valuable. The tube is to be retained, and the joint dressed antiseptically (by this I do not mean of necessity by Lister's method), placed on a splint, and left for two or three days, when it may be again washed out. The irrigation is to be continued every other day, at least until the wound is nearly healed; the drainage-tube is to be gradually shortened and ultimately discontinued.

This last method is the best and most certain means of treating large hydrarthrus with much fringe hypertrophy. It must, however, be employed with great caution; the temperature, and the condition of the system and of the joint being constantly watched.

Movable Bodies in Joints.

The singular bodies which sometimes exist, and which enjoy free or partially free mobility, within articular cavities, are very various in number, size, shape, constitution, and genesis, while in choice of locality they are far less capricious. They have indeed so strong a predilection for the knee-joint, that I estimate from collected cases 85 per cent. to occur in that articulation; the next most common seat is the elbow. Movable bodies occur, but rarely, in the hip and in the lower jaw. Sir Charles Bell found one in the ankle, and one has been seen in the wrist.

There may be only one such body in the joint-sac, or there may be vast numbers; in the former case, or when they amount only to three or four, they attain to a measurable and perceptible size; in the latter they are very minute, smaller than a grain of mustard seed.

If we except a certain irregularly formed class (detached but normal portions of the joint), we may classify them according to shape into four categories: 1. Oval or circular plates, bi-concave, bi-convex, or concavo-convex. 2. Globular, ovoid, or chestnut-shaped. 3. Conglobate, or mulberry. 4. Pyriform.

The constitution of loose bodies may be either cartilaginous,[1] bony, mixed bony and cartilaginous, fibrinous, or lipomatous.

Their genesis is even more variable than their structure.

(1.) They are formed from hypertrophied fringes, more especially from those prolongations which Rainey[2] has so carefully described as secondary sacculi; each villus of a fringe consists of a small projection carrying an afferent and an efferent vessel; from some of these hang, by thin stalks, very small, extravascular sacculi containing synovial fluid. When hypertrophy of fringes takes place, these sacculi enlarge; some become vascular, and simply form part of the dendritic growth, but in others hypertrophy leads to new development; cartilage-cells are deposited; the sacculi become nodules which grow while the stalks connecting them to the wall of the sac continue entire, and perhaps even longer. These, however, after a time break away, and the masses become free. By this means are formed many single and most of the multiple false bodies—those which are found in old rheumatic cases, and those which are an early manifestation of arthritis deformans. Lipomatous bodies, when two or three in number, are of like origin, as are also multiple lipomata, and among these I include that rare and singular condition called by Volkmann *lipoma arborescens articulorum*.[3]

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[1] In the first recorded case (A. Paré, 1558), the body was a cartilage; hence, movable bodies have commonly been called loose cartilages.

[2] Pathological Transactions, vol. ii. p. 110.

[3] Pitha und Billroth, Handbuch der Chirurgie, Bd. ii. Abth. ii. S. 576.

(2.) By metamorphosis of some part of the peri-synovial tissue through inflammatory or hyperplastic changes. Under the influence of some slight injury, or of a strongly marked dyscrasia, an inflammatory thickening or a clot of blood is deposited in the fine tissue just outside the synovial *intima*. Instead of being absorbed, this forms the nucleus of fresh growth; then a few cartilage-cells are deposited, and they, gathering hyaline material around them, cause further increase, until a little meniscus or plate is formed,[1] which by the unyielding quality of the capsule and ligaments, and by the action of contracting muscles, is pressed inward, and bulges a little into the joint cavity, pushing before it the synovial membrane. Increase in size exposes the body to still more pressure from without; it, therefore, intrudes, still with the synovial covering, more and more into the cavity, until it lies quite within it, but still attached by a fold of synovial structure, which also, until worn away, surrounds it after the manner of a mesentery. When thus far intruded, it comes also within the influence of the joint movements, which, moving it from place to place, drag upon the fold, elongate, and attenuate it until it at last breaks away. Bodies thus formed are meniscuses, either of cartilage or of bone; more rarely a lipoma, formed in the subsynovial tissue, becomes intruded into the joint in a similar manner; such intra-articular lipomata are solitary or in pairs. I removed a few years ago a pair of such fatty bodies; they had arisen one on each side of the ligamentum patellæ.

(3.) Another mode of formation is mechanically similar, but occurs under widely different circumstances. We have seen how in fully developed, rheumatic, but subacute, joint-inflammations, osteophytes are formed, and especially at the line where the synovial membrane is attached to the bone; we shall hereafter find that a similar but a more redundant hyperplasia takes place also in arthritis deformans. Sometimes the formative action extends from this locality to the periarticular tissues, certain spots of which become cartilaginous and bony; when that takes place, the same mechanical influences which are above described as forcing meniscuses of cartilage into the joint, thrust not unfrequently the osteophytic productions into the joint-cavity. Such is usually the genesis of irregular and conglobate bodies; they are sometimes pure cartilage, sometimes bone, more often mixed.

(4.) John Hunter ascribed the origin of loose bodies to blood-clots or fibrin-clots formed in the joint at some antecedent period. This method of formation is, however, uncommon; it is evident that it can only take place after injury, or after an attack of acute synovitis. Probably, after such events, only those clots which remain or become adherent can undergo metamorphosis into another tissue. Especially must it be remarked here that occasionally, years after the removal of one false body, several others form. These probably originate in bleeding from the operation wound into the cavity, but they may also be produced by an irritation of the wound, setting up local fringe-hypertrophy, or cartilage-formation primarily extra-articular.

(5.) Ecchondrosis, that is, direct growth of a cartilaginous pedunculated tumor from an articular cartilage, is a very rare event;[2] its etiology is entirely unknown.

(6.) Certain loose bodies have been proved to be portions of normal cartilage broken loose from their attachment. They may come from an interarticular meniscus,[1] or from an articular cartilage previously healthy,[2] or, as Mr. Teale[3] and more recently Sir J. Paget[4] have pointed out, a certain district of cartilage may die by a process of "quiet necrosis," slowly become detached without suppuration from the underlying bone, and then break away from its lateral surroundings and be shed into the joint.

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[1] A case by Mr. Shaw (Pathol. Trans., vol. vi. p. 328) illustrates in a most instructive manner this mode of formation. The body producing the primary irritation around which a cartilaginous mass gathered, was not, in this instance, a blood-clot, but a needle which had at some former epoch been thrust into the limb, and which lay for a time close to the joint.

[2] Unless, as I am disinclined to do, we take the early cartilaginous stage of an osteophyte for an ecchondrosis.

The above descriptions indicate that certain cases are in their origin a part of a diathetic disease, an outcome of grave changes in the joint-structure, a form of rheumatic synovitis, of arthritis deformans, or sometimes of obscure disease affecting all the articular tissues, generally traumatic in origin; in other cases, one or more false bodies are accidental occurrences, if such a term may be used; they arise, at all events, without the accompaniment of any severe or demonstrable malady, from a fortuitous deposit in the perisynovial tissue of a blood-clot, or of fibrin, or from enlargement of a single fringe-villus, which afterwards is excited to additional growth by the joint movements, or perhaps by being pinched between the bones. The mere presence of a smooth, hard, or soft body in the joint-sac is not necessarily productive of disease, particularly if it be quite free; but bodies which remain attached, by constantly dragging on the pedicle—and even sometimes such as are quite detached—often set up an irritation which tends to the production of hydrarthrus. Moreover, a distressing accident is very liable to occur, namely, intrusion of the loose body between the articular surfaces, or other sufficiently tense part of the joint; this produces intense pain, and is very generally followed by a smart synovitis, which, if frequently recurrent, will shortly be very detrimental to the integrity of the part.

Symptoms.—A disease whose etiology varies as much as that in question, or rather, it might be said, a condition which may arise from such very different diseases, can hardly present a homogeneous set of symptoms. But since those maladies of which the presence of false bodies is a part, possess certain well-marked characteristics of their own, we need here do little more than mention them. The tendency of subacute rheumatic synovitis to form multiple false bodies has already been mentioned, and the method whereby these may generally be detected has been described; and further consideration will be given hereafter to the bodies connected with the earlier period of arthritis deformans. Painless, or nearly painless, persistent, fluid effusion should always lead to the suspicion that false bodies, one or more, may be in the joint. Of course, these can only be detected by physical examination when the joint is not greatly distended, or when it has been partially emptied. But the presence of a solitary false body, or of a small number of false bodies, may remain entirely unknown until discovered by accident. The patient, believing that he is entirely sound, may by chance feel with his fingers that there is in one of his joints—generally the knee, less often the elbow—a very mobile little lump, which as soon as it is touched glides away like a frightened mouse into its hole (joint-mouse, "Gelenkmaus," the Germans call it), and it may be days before he finds it again.

More often the patient discovers the loose cartilage in a far more unpleasant manner. Thus, while walking, unconscious of any disease, still less of danger, he may be suddenly seized by a pain so severe that he turns sick and faint. Unless some support to which he can cling be at hand, he falls. The joint being fixed by spasm of the muscles, the pain gradually relaxes, and at the same time comes a feeling that if he could only bend, or otherwise change the posture of the limb, he would be relieved; and if he be bold and fortunate, this really happens; but sometimes such movement is, or seems, impossible. The patient has to be taken home; perhaps a surgeon moves the joint, and at once relieves him; or he goes to bed unrelieved, and, if he fall asleep, probably wakes in the morning to find that nothing is left of his trouble but a little aching, and perhaps some swelling of the joint.[1] This sort of attack is attributed to the body having intruded between the joint surfaces, which it forces apart. Volkmann declares this to be most improbable, and believes that the body gets jammed somewhere between the sides of the joint-end and the synovial membrane;[2] but in opposition to this idea it must be noted that on account of the imperfect fitting of the femur to the tibia, the gliding motion of the latter bone over the condyles is exactly the sort of movement that would be most likely to entangle a loose body. Moreover, if the body lay during such an attack between the synovial membrane and the outer surface of the bone, surely it would in some one of the many reported cases have been found; but I find no record of such a discovery during an attack. It is quite true that the loose body is sometimes so large that we can hardly conceive it to be capable of getting between the bones. But then there is no doubt that equally painful symptoms would be caused by its slipping into the intercondyloid notch, and becoming entangled between a crucial ligament and the bone, or between the two ligaments. When the surgeon sees a patient just after one of these attacks, he had better, if the joint be pretty full of fluid (for synovitis frequently sets in), postpone any search for the loose body until the sac is nearly empty. Even under favorable circumstances the body may not be at once detected; it may lie in some cranny, and there be quite concealed until dislodged. Generally, it is well to explain the condition of things to the patient, and beg him to spend occasional leisure minutes in a "mouse-hunt" for himself; but if the surgeon search for it, this must be done with the lightest possible touch, and with a hand acutely alive to any change of form or abnormal projection. When such a projection is found, it must not be directly pressed upon, but is to be surrounded at a little distance by several fingers of both hands, which are then made gradually to approach each other until all channels of escape are cut off; then a finger of each hand can be used to feel the body, to impel it hither and thither, examine its size, consistency, etc. The most common places for finding these bodies are the lateral surface of the outer condyle, and next that of the inner condyle; but I have also found them in front of the femur, just above the patella, and once or twice on the tibia just inside the ligamentum patellæ.

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[1] See a case by Mr. Brodhurst. Path. Trans., vol. xviii. p. 214.

[2] See Klein's case in Virchow's Archiv, Band xxix. Heft 1 und 2.

[3] Med.-Chir. Trans., vol. xxxix.

[4] St. Bartholomew's Hospital Reports, vol. vi.

When by care the existence of a movable body in connection with a joint has been made out, the surgeon must ascertain whether it is really inside the articulation; in many cases, and especially when the substance enjoys a wide range of motion, this is very easy. But some that are really in the joint move but a very little way, and there are about the knees of some persons certain irregularities of the fascia, or lipomatous nodules, which have a degree of mobility, and might easily be mistaken for intra-articular bodies; for instance, that fold of the fascia which covers the vastus externus, a little way above the outer edge of the patella, has frequently, to my knowledge, been taken for a movable body in the joint. No lump should be considered as moving within the joint if its range of motion be so restricted that it is always found in one place, with its long axis always in the same direction, nor unless it can be induced to hide itself under some recognizable anatomical part; as, for instance, under the patella, the tendon of the rectus, a lateral ligament, or the ligamentum patellæ.

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[1] This sort of attack is sometimes due to the subluxation of a meniscus, or to some other internal derangement of the knee.

[2] Loc. cit., S. 580.

I do not think it possible to make out whether a body in the joint be cartilaginous or bony, or a mixture of both cartilage and bone; the softness of a lipomatous body[1] will generally enable the surgeon to distinguish it from other varieties.

The shape of the body can generally be roughly made out; but being felt through a considerable layer of soft parts, it commonly appears larger than it really is.

Treatment.—We may divide the treatment into palliative and curative; to the former belong all the methods that have been devised for retaining the false body in some harmless part of the joint-sac. Among these are various forms of bandage or plaster. The simplest, and by no means the least efficacious arrangement, is to cut a hole, of a size a little larger than the loose body, in a piece of adhesive plaster, and having manœuvered the body into some such advantageous position as on the lateral surface of either condyle, to apply the plaster in such a way that the body lies well within the hole. The same sort of arrangement may be carried out with an elastic or other bandage, or with a knee-cap, having an opening at the side corresponding to a part of the joint into which the body can be easily propelled. In certain cases, the use of a knee-cap stiffened behind by a steel splint, is the best treatment, and this more especially applies to joints which contain a large number of false bodies, for, as we have seen, such a condition is but a symptom or a consequence of disease, not merely of the synovial membrane, but of the whole joint-apparatus. Such a state could not be benefited by removal of the growths, which would only rapidly recur, but might, in all probability, be aggravated by the operation. But if dealing with one or two loose bodies, the surgeon will avoid disappointing his patient by at once informing him that any form of bandage can give but temporary and unreliable security, since sooner or later the body will escape from its control.

Another device is to fix the body in some desirable locality by means of a serre-fine, or by passing through it and through a fold of skin a hare-lip pin or wire suture, leaving this *in situ* until the resultant inflammation has glued the substance to the synovial membrane, or necessitates removing the instrument. This method cannot be very highly commended; it is by no means free from danger, since it is impossible to be sure that the inflammation produced by such a wound will reach the point intended and go no farther. Moreover, even if all go well—if the body adhere and inflammation subside—the movements of the joint are apt very soon to loosen or break down the new adhesions, when all the troubles recur. This accident we may endeavor to prevent, or at least to postpone, by using one of the bandages above described; but even with all possible precautions, recurrence of trouble is so common that it is well to warn the patient of its possibility.

The only real cure for the disease is by removal of the loose body. The operation may be performed in one of two ways—the direct and the indirect —the latter being sometimes called the subcutaneous method. The direct method was the earlier in priority, but was then almost superseded by the indirect, which again has given place to its older rival. The reason of this oscillation is as follows: Some twenty-five or thirty years ago, surgery, plentifully skilful and brilliant, was at the same time somewhat slovenly, not to say uncleanly; wounds of cavities, serous and synovial, were almost sure to suppurate. Now, whatever may be thought of the germ theory, of the spray, and of all the other minutiæ of Listerian antisepticism,[1] there is no doubt that cleansing the hands, the instruments, and the patient's skin, by means of a powerful disinfectant, is a considerable safeguard against suppuration. Thus, up to about thirty years ago, the direct extraction of loose bodies from joints was a very dangerous proceeding, and when the subcutaneous method of Delpech and Stromeyer became known, it was extended from the mere division of tendons to other operations, and among them to the excision of loose bodies from joints. The operation was largely practised, but very often failed, until Square, of Plymouth, introduced a somewhat modified method, dealing very freely with the synovial membrane and the periarticular tissues. It is his method which will be described.

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[1] I have compared the sensation imparted to the hand by one of these bodies to the feel of an oyster squeezed between the finger and thumb till it slips away.

The instrument must be broader than the usual tenotome, longer also in the cutting part, and, in order to fill or plug the rather big cutaneous opening, thicker and stronger in the non-cutting part. When this instrument has been introduced under the skin, it is moved to and fro, partly dividing, partly breaking down the periarticular tissues, until a cavity has been prepared, sufficient for the body to lie in when extruded; then the synovial membrane is pretty freely opened, so that there shall be no impediment to squeezing the body out of the joint and into this new-formed cavity. Here it is left for some days, until the synovial wound has had ample time to heal, when it may be cut down upon and removed.

The direct method is performed by manipulating and keeping the body in some part of the joint readily accessible from without, and then shifting the skin over it as far as it will go; the surgeon, with a very sharp knife, cuts straight into the joint, not on the cartilage, lest the pressure of his scalpel should cause it to slip away; but a little on that side to which he has learned that it most readily passes. The opening in the synovial membrane should be quite free enough to let the body pass easily, and a little pressure towards the opening should cause it either to jump quickly or move slowly, to glide out of the wound; in either case, the track should be closed by the pressure of an assistant's hands immediately behind the body. Sometimes, in spite of all proper arrangements and skill, the cartilage will not come to the synovial opening, and it may be necessary to pass in a fine pair of tenaculum forceps to seize it and bring it forth. Occasionally it will be found to be still attached to a pedicle, which may either be twisted until it gives way, or simply cut. If the spray and carbolic acid have been used, the site of operation should be drained. The surgeon may, if he choose, pass a probe through the operation wound into the joint, and on to some dependent part of the sac, cut down upon the probe's point, and thus draw in a drainage-tube; or he may simply pass a drainage-tube into the operation wound, and, if he have been able to choose a dependent part, this will be the safest plan;[2] nor should the tube do more than just intrude into the synovial wound. If the simpler and less irritating dressing with boro-glyceride have been employed, no drainage-tube, or merely a tube just passed into the lips of the outer wound, is necessary.

The after-treatment consists chiefly in affording complete rest to the joint, one of the many splints already so often referred to being applied. The wound should be dressed in from twenty-four to forty-eight hours, according to the amount of secretion, and the splint should be arranged in such wise that the dressing may be done without disturbing the limb.

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[1] I place the words thus, because there are other antiseptics and other modes of insuring their action than those introduced by Lister.

[2] I lately saw a case, under the care of an excellent surgeon, in which all the Listerian precautions had been employed, including the use of a drainage-tube through the joint. I attributed the violent suppuration that ensued to the irritation of the synovial membrane by this foreign body.

In comparing the results of these methods, we find that the direct method is somewhat more dangerous to life and limb than the indirect, and that the latter, though by no means free from danger, is especially liable to failure, by impossibility of extruding the body through the incisions made. These two sorts of mishap were at one time, according to Larrey's tables, so frequent, that more than half of the cases operated on either failed or were fatal.

Here subjoined are two tables, that of Larrey, coming down to 1860, and one of my own, embracing cases recorded since that date.[1]

H. Larrey (1860).

	Direct.		Indirect.	
	Number.	Per cent.	Number.	Per cent.
Success	98	74.8	19	48.7
Death	28	21.3	5	12.8
Failure	5	3.8	15	38.4

Barwell.

	Number.	Per cent.	Number.	Per cent.
Success	44	91.6	29	72.5
Death	4	8.4	1	2.5
Failure	—	—	10	25.0

Joint Diseases which are due to Osteitis.

I. Acute Articular Osteitis.

We have hitherto had to do with a class of diseases which commence in the synovial tissue and its immediate neighborhood. Those which primarily affect the bones, and which after a time spread by one of various ways to the joints, must now engage our attention. They are not less interesting than diseases of synovial origin; in certain points of view their study is more important, since in many cases their early recognition—before the joint itself has become deeply involved—may enable us to prevent a long process of disease which often has a most undesirable termination. The maladies in question attack the bone in the immediate vicinity of a joint—the articular extremity in adults, the epiphysis or shaft-end in younger people; in both, a short bone, as of the carpus or tarsus, may be the seat of disease.

A very severe disease of bone, namely, acute osteo-myelitis, or acute osteitis, must first be studied. By some authorities the disease is ascribed to systemic causes, and is likened to erysipelas or phlebitis (osteo-phlebitis). By others it is ascribed to local chilling or traumatism. But the attack often occurs when no or very trifling exposure or injury can be traced; it is severe, out of all proportion to the injury received; and it is not unfrequently multiple; we cannot therefore, I conceive, logically ascribe a disease which is so violent to a very slight external cause, although some chill or hurt may determine the time and place of its commencement.

Acute osteo-myelitis is especially a disease of young life, during which period the bones, undergoing rapid growth and considerable change, are extremely vascular. The preference of the malady, too, is markedly for those parts in which there is the greatest amount of growth, and therefore most vascularity, viz., in the following order:—

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[1] The tables may be taken somewhat as guides to indicate the results of the two methods, but it need hardly be pointed out that the earlier statistics do not apply to the present time, and that in collections of published cases the numbers of failures and deaths are very much below the reality.

1. Lower end of femur.
2. Upper end of tibia.
3. Upper end of ulna, lower ends of humerus and of tibia.
4. Upper end of femur.
5. Upper end of humerus.

The local manifestation begins with hyperæmia of the parts within the bone, namely, if the site of disease be at a joint-end, hyperæmia of the subdivided medulla and of the cancelli; then inflammatory products, solid and fluid, are rapidly poured out, and extravasation in larger blotches or smaller specks takes place. A little away from the chief focus of disease, where the action is a little less turbulent, granulations are thrown across the medullary cavity, thus cutting off the inflammation and its morbid products from the neighboring healthy parts. If the disease remain within the same limits, these granulations become further developed into a coarse, fibrous or fibro-cartilaginous structure, which in some cases is ultimately ossified. If the disease spread further along the central cavity, the granulations rapidly dissolve away. Whatever their fate may be, the course of the disease at its point of chief action is not thereby affected. The medulla, under the influence of inflammation, loses its consistency, and rapidly breaks down into liquid oil, with which the inflammatory fluids and the extravasated blood intermingle. All this new material, being inclosed in a bony case with unyielding walls, produces very considerable tension or pressure inside the cavity.

But the action is not confined to the contents of the medullary canal. It either simultaneously falls on, or very soon spreads to, the bone itself and the periosteum.[1] Hence, in all cases we find both these structures greatly changed; the bone is softened and red, and bleeds if cut; the Haversian canals are enlarged, and contain, besides the dilated vessels, inflammatory exudations, here and there extravasations, and oil; while the periosteum is very hyperæmic, softened, and separated from the subjacent bone by an effusion of blood-stained serum, by extravasations, and (save in diffuse cases), at the confines of the disease, by granulations. Even at this early stage all these may be mixed with blotches and drops of oil—dissolved medulla—which have been forced out of the cavity by the intraosseous pressure above alluded to.

In the mean time, the parts surrounding the affected structures also participate in the inflammation, sometimes sooner, sometimes later, according to the more or less phlebitic nature of the case. The deep veins leading from the inner or from the outer parts of the bone are engorged, and either by becoming themselves inflamed, or from absorption of pus, or from both causes, permit the formation of thromboses, which often extend to a considerable distance from the focus of disease, and involve veins having no direct connection with the bones. Hence, extravasations and blood-stained serous exudations occur in the track of vessels, chiefly in the intermuscular spaces; and in these, beginning with the deeper ones, the tissues tend to suppuration, and, if the disease persist, do actually suppurate.

Thus this stage presents, supposing a transverse section to be made through a limb thus diseased, the following appearances from the centre outward: The interior of a bone (cancellous structure), which is deeply red from hyperæmia and blotched with extravasations, and from the cavities of which flows medullary oil, also somewhat tinged. The substance of the bone itself is red and softened; around it lies blood-stained serum intermingled with oil, with here and there a fugacious granulation. Outside this, and containing it, is the congested and softened periosteum, surrounded by muscles separated from each other by intermuscular spaces, in which turgid veins ramify amid reddened serum and discolored extravasations.

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[1] In describing these pathological changes I am accustomed to teach that the outer and inner membranes of a bone are in direct continuity one with another by means of the Haversian lining-membranes and canalicular fibrillæ; that there is complete reciprocity of action between those two structures, retarded only a little by the greater or lesser thickness of the bone, that is, by their greater distance one from the other.

Up to this point it is possible, though unfortunately rare, that retrogression may occur; the vascular turgescence may subside; the serum may rapidly, the extravasations more slowly, be absorbed; the intraosseous pressure may diminish, and then cease; the periosteum may again come in contact and form connection with the bone; all the morbid conditions may clear up, and this without any necrosis or suppuration. But such an event is very rare; and, if it is to take place at all, retrogression must commence not later than the first week, for the next stage follows quickly—occasionally so quickly that this earlier stage, though doubtless no inflammation can produce pus at its very commencement, appears to be clinically indistinguishable from it.

The next stage is the suppurative. It consists in the change of the mere exudative stage into that of pus formation. The districts which have been described above as occupied by extravasations and oil-globules mixed with serum, now contain the same elements, mingled with more or less discolored and generally offensive pus. But now come the points of chief importance in this change: The bone throughout a smaller or larger district dies, and the veins, already filled with soft, partially broken-down blood-clot, are exceedingly prone to absorb the unhealthy fluids, and produce rapid pyæmia.

Whenever the diseased action takes place near the epiphyseal line—and, indeed, this is the more usual situation—the junction is involved in the action, and the epiphyseal end of the bone is cast off; a circumstance which led Klose[1] to name the malady "Epiphysentrennung" (separation of epiphyses); and this part, in the severe cases we are depicting, usually dies, and lies as a sequestrum among the discharges.

Morbid Anatomy.—Such very acute osteitis is not common in England, but in certain parts of Europe it appears to occur in the form of an epidemic, and it was from this sort of case that Chassaignac and Klose drew their highly colored pictures. Its morbid anatomy may be summed up thus: In the bone cavity are found large districts of purple, intense hyperæmia, with blotches of extravasation, and dark-colored and offensive pus, mixed with disintegrated medulla. Outside the bone are very much the same materials; the bone itself, dying or dead, is of a greenish or black hue. All this is contained in a highly inflamed and distended periosteum, outside of which the soft tissues are soaked in a blood-stained serum or pus. The veins are turgid with semi-coagulated blood, discolored, and evil-smelling. The separated epiphyses lie bathed in pus at the ends of the bones. But generally the course of the disease, though more than sufficiently violent, is less acute than above described. The same, or probably less intense local changes are brought about more gradually, with a distinct incubation period—an interval of inflammation previous to pus formation—and then a slower suppuration, and a diastasis, whose more gradual steps may to a certain extent be followed, for sometimes this occurs in an incomplete form. Ulceration taking place all around the junction forms a deep groove, but not a complete separation, the epiphysis becoming twisted on the shaft. In certain other cases, again, the epiphysis by further ulceration becomes entirely separated, but, owing to the slower method of the process, does not die. On the contrary, it not only continues to live, but may again become attached to the shaft, though in an abnormal, and perhaps very deforming position. Such was the case with the patient from whom the preparation here depicted was taken. With great difficulty I steered her through all the dangers of acute osteo-myelitis; but she could and would bear no appliance to the limb. The epiphyses were completely separated, and when she had sufficiently recovered I advised amputation. This was refused for a long time; when accepted, the epiphyses were reunited, but in very bad position. The shaft of the femur was extensively diseased, and suppuration was wearing out the patient's small amount of strength.

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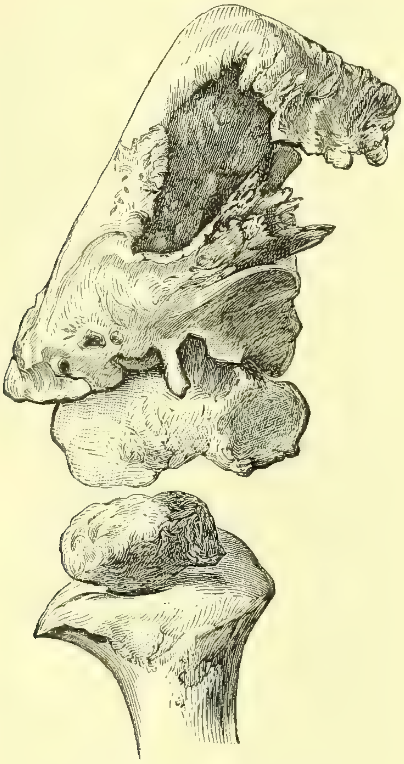
[1] Prager Vierteljahrsschrift, 1858.

Fig. 648.



Acute osteitis; separation of epiphyses.

This disease has certain relationships with erysipelatous phlebitis, and particularly must it be pointed out that the malady is sometimes multiple; indeed, an instance is mentioned[1] in which every important epiphysis of the body was separated. In this, as in certain other cases of multiple disease, the primary attack preceded, by a considerable interval, the others, which appear to have been pyæmic. In some other cases the different attacks have been almost simultaneous (phlebitic). The general or systemic condition has been, till now, left unmentioned, that the local pathology might be more succinctly given; but before passing on to consider the articular phenomena, it must be noted that the sharp pains and the rigors which usher in the attack, are succeeded by strongly marked pyrexia, the temperature reaching 104° or 105° F. or occasionally even more. Very soon the fever assumes a typhoid character, increasing and deepening if the disease is to end fatally.

It is singular that the joint-affections contemporaneous with and in close proximity to such tumultuous disease, should often be of a very mild nature. Herein we must make a distinction—quite overlooked by Chassaignac[2], by Klose, and by Paul—that in many cases, especially in those which have been caused by injury or by some definite exposure, an articular affection may precede, or at least be cotemporary with the bone disease, and yet be in no way dependent upon it. Such simultaneous disease may even improve and almost disappear, while the osteitis is in progress and approaching its culmination. Moreover, these same writers insist too strongly on the constant severity of the secondary, the dependent joint-disease, which may be, it is true, a severe suppurative synovitis, with or without pyæmic affection of distant joints, but is more commonly a simple sero-synovitis, due to extension of inflammation from the periosteum. Another not unusual complication is a form of hydrarthrus with considerable fringe-hypertrophy which is rapidly produced.

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[1] Demme, Wiener Medizinal-Halle, 1864.

[2] Gazette Médicale, 1854, Nos. 33, 35, 36, 37.

The suppurative synovitis is caused by the products of inflammation passing into the joint cavity; but this has not the same violence as when pus is suddenly poured into a healthy joint, for the disease has progressed, however rapidly, still by degrees along the periosteum, as also through the bone and cartilage. Thus the synovial membrane is already in a morbid condition, and the cartilage rarely gives way, largely and suddenly, so as to admit a flood of inflammatory fluids into the joint, but is rather perforated in small holes, giving passage to slow transudation.

Diastasis does not itself produce any diseased action in the joint, save that of position, unless the line of the epiphyseal junction lie within the synovial area, in which case there occurs a more or less sudden influx of pus into the cavity, and the most acute suppuration of the joint may follow. When, however, very acute osteitis attacks, not the end of the shaft, but the epiphysis, the joint-affection more immediately accompanies the disease. Acute epiphysitis is a rarer, and, as a rule, a more destructive malady.

From the above account it is evident that we have to do with a more and with a less severe affection; the former is, as far as our present knowledge goes, closely related to phlebitis, and is combined with or immediately followed by septicæmia and pyæmia. The latter, though also an osteo-myelitis, is circumscribed, does not produce inflammation or thrombosis of veins outside the bone, and is often overlooked, its symptoms being very obscure, and frequently ascribed to rheumatism. If its course be favorable, the periosteum will again adhere, and even the bone, though sclerosed, and perhaps for months the seat of obscure and intermittent pains, may eventually quite recover. Or a certain portion may die, around which new periosteal bone will form, when the case takes on the usual well-known form of osteitis and thickening around a central sequestrum, which, after a year or more, will produce abscess in the soft parts, and may be removed by operation.[1] Again, in certain cases no portion of the bone will necrose; but there will remain an intraosseous abscess, which may at once give rise to severe trouble, or may become surrounded by sclerosed bone and slowly desiccate. Occasionally, too, in the cancellous structure, the pus, scattered in a chaplet of abscesses, will also dry up. When, as often happens, fresh disease sets up new symptoms, these caseated deposits may be revealed, and are very likely to be mistaken for tubercle.

SYMPTOMS.—This disease usually attacks persons under seventeen years of age; sometime babies of a year old. Nine months is the youngest age at which I have seen it. In some instances an epidemic influence appears to have generated very many cases of acute osteo-myelitis in a certain area; and this, when recognized, greatly facilitates the diagnosis. Occasionally, in either epidemic or sporadic cases, some definite injury or exposure precedes by some days the attack. The first symptom may be a severe rigor, followed by pyrexia; such cases are more likely to result in the phlebitic variety of the disease, than when the primary sign is severe pain and aching of the limb. The pain, be it lancinating, burning, aching, or bursting in quality, is always accompanied by a powerlessness which is very characteristic, which the patient feels as a sensation of great weight—as though the limb were of lead—and which the surgeon sees in every motion of the sufferer. If from any cause its position must be changed, the patient either drags the limb hanging passively from the trunk, or lifts it with his hands.

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[1] While writing these pages, I have removed from the lower part of the femur a sequestrum, which was surrounded by new periosteal bone, and which was more than one-half the circumference of the shaft, embracing its entire thickness, and two inches long. The patient, a child aged 10, had received a blow two years previously, and after a fortnight had suffered severe pains and fever, which lasted a month; after this, though she slowly got better, she never recovered perfect or painless use of the limb.

In the worst cases, those of the osteo-phlebitic variety, the general symptoms are, severe and remittent rigors (these are, in some cases, not strongly marked), with considerable pyrexia, the evening temperature reaching to 105° F. or more; the tongue furred, and brown in the middle; appetite entirely absent; insomnia almost persistent; constipation at first, perhaps followed after a time by diarrhœa and vomiting. Icteroid coloration of the skin is generally present.

In the less urgent cases, these symptoms are greatly modified; the pyrexia is much less marked, and the disturbance of the digestive functions less apparent; yet there is sufficient evidence of illness to cause us to recognize the presence of some inflammatory disease, to the locality of which the pain clearly points.

Yet for about five days, more or less, from the commencement of the malady, no local change can be perceived; afterwards a deep, local swelling may be detected, which is œdematous at the surface, and doughy or boggy beneath, while still deeper pressure reveals a perfectly hard substratum. This enlargement ceases by a sudden edge, beyond which the limb is, to the touch, normal or nearly normal. The tumefied part is exceedingly tender upon deep pressure; but beyond the boundary of swelling the tenderness ceases quite abruptly. This sharp limitation of swelling and tenderness is a very important characteristic of the disease.[1]

Again, there is an interval of from five to nine days, during which little alteration takes place except increase of swelling, and then begins a change in the color of the skin.[2] In my experience this is bright-red or reddish-purple, and shiny, the color disappearing momentarily on pressure with the finger; but in certain cases, especially of the epidemic, phlebitic form, it is, according to Demme, of a dirty clay color as long as acute œdema is present. Large, distended veins ramify beneath the integument, but in the cases marked by red coloration they are much less perceptible (though present) than in the others.

Abscess, except in the most acute cases, can rarely be detected from the surface till after a fortnight.

These symptoms, in their entirety, form a picture so different from ordinary phlegmonous erysipelas, that mistake is hardly possible; and to make an incision for merely diagnostic purposes (Chassaignac) is not, in my opinion, justifiable. Oil drops (from the disintegrated medulla), which under such circumstances would be found in the pus, might also be due to certain other forms of disease. Incisions can only be justified as a resource of treatment.

When the surgeon perceives, during the course of the above symptoms, the sudden appearance of a marked and peculiar deformity about the joint, he may suspect diastasis, and must carefully watch the case for the next few days, during which the distortion gradually, though pretty rapidly, increases. The diagnosis between separation of an epiphysis and pathological dislocation is in part rational, in part physical; thus, the former can only occur during early life, and is a much more common sequela than the latter of acute osteo-myelitis. The abnormal mobility is greater and of a different sort from that of luxation; it takes place above or below the joint, the relative position of whose component parts, condyles, etc., remains unchanged.[1] After a few days the truncated end of the shaft, very different in shape from the joint-end, makes a projection beneath the skin. Occasionally the edges, both of diaphysis and epiphysis, can be felt. It must here be noted that not unfrequently muscular apophyses also become separated.

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[1] See also Chassaignac, loc. cit.

[2] Demme states that this coloration does not take place until the periosteal abscess approaches the surface. I am, however, in a position to affirm that this is by no means always so; I have seen intense redness or purplish redness of the skin, in two or three cases, while the abscess has been still very deep.

The period at which diastasis occurs varies very much, according to the violence of the disease. In bad cases, those that usually either prove fatal or require amputation, the separation occurs about the tenth day. When this event is deferred beyond the month, there is much hope of recovery, but, of course, with much deformity and crippling. Even when all acute fever has subsided, chronic suppuration and extensive bone disease may call for amputation. The primary joint-disease, that which arises prior to or simultaneously with the osteo-myelitis, and which is due to the same cause, may be very slight or more severe; in the latter event, it may very considerably embarrass diagnosis. In young children—those under six years—a tolerably severe traumatism may set up a smart sero-synovitis; in older persons, an exposure to cold may first induce a rheumatic synovitis, together with vague rheumatoid pains in other joints. Thus, in the one malady an attack of severe local pain is very apt to lead to the conclusion that a simple synovitis is assuming the suppurative character; in the other condition, the symptoms greatly resemble those of acute rheumatism expending its chief force on a single joint.[2] As regards the differential diagnosis, it must be observed that in osteo-myelitis the limb lies straight, and that the abnormal flexion of suppurative synovitis does not occur; the appearance of passive helplessness is characteristic; the locality of chief pain and tenderness is different, and, unless the joint itself be much inflamed, the points of synovitic tenderness are absent. The pyrexia of osteomyelitis is of quite a different type from that of rheumatic fever; the quality of the urine is not that of uric-acid disease; the sweating is not profuse, but, on the contrary, the skin is generally dry. When sweating does come on, it has not the great acidity of rheumatic perspiration. In locality and quality, the pain is quite different from that of rheumatism, unless neuralgic rheumatism, and this the temperature excludes.

The joint-affections consecutive to and dependent on acute osteo-myelitis are often, as already stated, comparatively mild, and may, indeed, in the violence of other symptoms, escape notice. A serous or purulent synovitis, much masked by surrounding tumefaction, hardly forces itself into notice; but, if it should become suppurative, the flexed position of the limb, combined with tension below the place of original disease, and a probable sudden increase of pyrexia, combined with or preceded by rigors, should at least awaken suspicion.

Pyæmic complications, involving either the internal viscera or other joints, manifest themselves by symptoms which have already been discussed both in this article and in other parts of the Encyclopædia.

TREATMENT.—Chassaignac, who first drew attention to acute osteo-myelitis,[3] followed by G. Roux, Klose, and Gosselin, advocated immediate, free incisions down to the bone. This treatment was eminently unsuccessful, being in the vast majority of instances followed by pyæmia and death. A few years afterwards Dr. Demme refuted these views, and insisted on the necessity of avoiding any opening of the skin, as long as the more acute phase of pyrexia continued.

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[1] In case there is much swelling, these positions cannot well be made out.

[2] Demme entitled his paper, in Langenbeck's Archiv, Die pseudorheumatische Progresse.

[3] Mémoire sur l'ostéo-myélite. Paris, 1854. Gazette Médicale, 1854.

My own experience of this malady, which has not been small, inclines me so far to the views of Demme, as to think that incisions should not be made merely for routine's sake, but that there are, nevertheless, certain cases in which either extreme tension or early suppuration renders incisions absolutely necessary, and that then, if judiciously employed, they are salutary.

The treatment, therefore, should be carried out on the following lines: After administration, if needful, of a purge, the patient is to be placed on a nutritious and supporting diet, stimulants being in all probability necessary. Opiates by the mouth or subcutaneously must be given. The limb is to be placed at entire rest on a splint, and especially should be slung; and of all local applications, compresses, put on hot and covered with thin mackintosh, are, in my opinion, the most efficacious; they cause transpiration, appear to relieve the distended vessels, and tend to keep the blood within the veins liquid and in motion.[1] If it be wished to add the acetate of lead or tincture of opium to the fluid of the compress, there can be no objection. From day to day the part must be examined, attention being paid to any centrifugal spread of the inflammation, and more especially to any increase of swelling, or to fluctuation indicative of suppuration.

When the deep, hard swelling softens, or the change of color, already described, takes place—which occurs in from five to fourteen days—an opening will, in all probability, be desirable. Occasionally these symptoms are not so strongly marked but that the surgeon may have some hesitation, in which case an exploratory trocar may be first introduced. In other cases, combined with the above symptoms, a spot may be found at which fluctuation is perfectly distinct; here an opening may be made long enough to admit further exploration with the finger. The great object in treatment at this stage, I have no hesitation in affirming, is evacuation of pus from the vicinity of the bone, as soon as detected. Hence, the opening must go through the periosteum, and, if it have to extend through much thickness of tissue, effusion of any great quantity of blood can be avoided by making the deeper parts of the cut not very long, introducing into the periosteal wound a pair of dressing forceps, and, by rapidly opening the blades, tearing up the rest.

The surgeon, however, must procure a sample of the pus, as free as possible from blood, and examine if any considerable quantity of oil float on its surface; and if that be the case, he should perforate the bone. He need have no fear of missing the spot where intraosseous pressure is well marked, since it is quite sure to be opposite the place of subperiosteal abscess; nor need he lie under apprehension of doing harm. No complication of instruments is necessary; a simple, well-tempered, and sharp, carpenter's gimlet is all that is required. Throughout the operation, care should be taken not to injure or unnecessarily tear the periosteum. When all is complete, the wound should be well washed out with an antiseptic; a solution of chloride of zinc, forty grains to the ounce of water, is, I think, the best, but carbolic acid may also be used. Unless very extensive, no part of the wound should be sutured, but it may be loosely filled with lint or absorbent cotton steeped in an antiseptic fluid. A drainage-tube should be passed into the furthest depths of the wound, and retained for at least a few days. Many cases under this management completely recover.

If, in spite of all efforts, the disease continue to spread, a repetition of the operation, as far as may be wise or as the patient's strength may permit, must be carried out. But if the spread be rapid and the appearances indicate wide destruction, the repair of which will of necessity destroy the patient, amputation is the sole resource. If, however, symptoms of pyæmia, which must be carefully looked for, appear, the treatment must be carried out on the lines already indicated (see page 294).

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[1] Demme recommends the application of a very strong tincture of iodine, 60 or 70 grains of pure iodine to the ounce of absolute alcohol, and this to be repeated to the verge of vesication. I have not traced any special advantage to this treatment; it adds to the pain, and the horny condition left may give rise to subsequent trouble.

During the whole course of the disease, the surgeon must endeavor to prevent diastasis by enforcement of rest in a good position; and especially if the parts about the knee be affected, a straight posture must be maintained, as otherwise the mere power of the flexors will, without blow or sudden movement, produce that displacement. But, except in the more rapid or osteophlebitic form, separation of the epiphysis is not a sudden event, and, therefore, while the groove of separation (see page 347) is being gradually formed, the greatest care will be necessary to prevent any movement which might fracture the remaining connection; for while any portion of attachment remains, separation may be avoided and repair hoped for. When diastasis has taken place, we need not absolutely despair of reunion, provided that the neighboring bone be fairly sound; the problem, and it is often a difficult one, is to insure that union shall take place in the best possible posture, for at all joints there is great tendency to deformation towards the side of flexion. No appliance seems so well calculated to insure this result as the plaster-of-Paris bandage, applied while, by extension or otherwise, the limb is held in position. If mouths of sinuses, or the remains of abscesses, be anywhere found, corresponding openings must be made in the bandage.

The management of the accompanying joint-disease must depend on its form and severity. If the surgeon have to do with a mild joint-affection tending to become chronic—and, if so, remarkably obstinate—he will employ such treatment as has been described in previous pages. The more severe affections, too, must be treated on principles already laid down. Especially would I here point out, that, if the synovial tissues suppurate, free incision and thorough drainage are particularly necessary, and that the opening thus made must be utilized for making a careful investigation into the state of the bone.

In case one or both epiphyses be found lying in an abscess, loose and necrosed, there will be no possibility of restoring the joint, nor, as long as the sequestra remain, of procuring anchylosis; moreover, the presence of the dead material keeps up suppuration, which may go on to the exhaustion of the patient. It is therefore evident that these must be removed; but there is some choice as to the method, which must be guided partly by the condition of the patient's health, partly by the anatomical position of the joint involved. Thus, if the patient have suffered much, or if suppuration have been considerable, so that the bodily powers are unequal to a rather long and arduous work of repair, it may be desirable, whatever be the joint involved (except the hip), to amputate; otherwise, the surgeon may for most articulations cut into the abscess widely enough to remove the loose ends, drain the cavity thoroughly, and, keeping the part at rest, endeavor to obtain such union, fibrous or otherwise, between the ends of the shafts, as shall enable the limb to serve some useful purpose. This, especially, may be the result with the joints of the upper extremity, and more particularly with the elbow.

If the disease be at the knee, its most frequent seat, sundry considerations become involved. It is very doubtful indeed, if, the necrosed epiphysis or epiphyses being removed from an abscess-cavity, it would be possible to secure synostosis of the femur and tibia; and if this should not occur, the limb would be very useless.[1] Moreover, if synostosis should take place, the limb would hardly grow from the end which had shed its epiphysis, and if the patient were in early life, a very short limb would result. In all probability, therefore, when an acute osteo-myelitis has caused separation and death of one or both epiphyses about the knee, amputation will be the best treatment, that which is most likely to save life, and that which will leave the most useful form of member behind; a good stump being better than a short, feeble, and deformed limb.

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[1] The condition of things is very different from that in which an excision of the knee-joint is usually performed.

II. Chronic Articular Osteitis.

Osteitis is much more frequently subacute and chronic than acute, so that, both in private and in public practice, we constantly meet with the first-named varieties in different forms affecting adults and children. Chronic bone-inflammation may be due to various constitutional dyscrasiæ—*e. g.*, syphilis, scrofula, or rheumatism—or may be merely traumatic and local. It is not desirable that I should here discuss the histology of osteitis further than may be necessary for the elucidation of our present subject.[1] It must, however, be said that: (1) Osseous tissue, even that apparently solid case which surrounds the medullary canal of a long bone, is traversed and pervaded by channels containing vessels and membranes, and the small non-vascular districts between those canals are studded with stellate cells, which, together with their branches, subdivide the tissue into microscopic spaces; (2) the nutrition of the bone is effected by fluids conveyed along these channels, first, by the vessels into the Haversian canals, and secondly, from thence by the minuter passages, into the lacunar spaces; and (3) by means of these minute membranous ramifications, the periosteum and endosteum are placed in close interrelation.[2] These are all concerned in the nutritive mechanism of the bone.

In parts where, for the sake of combining increased size with lightness, the bone elements, instead of being concentrated into an apparently solid mass, are scattered in thin plates inclosing interspaces (cancelli), vessels, and therefore Haversian canals, need not be channelled through the tissue itself, but the cavities contain the arteries, and are lined by subdivided prolongations of the vascular endosteum; nevertheless, lacunar spaces and cells are still necessary. In fact, bone is connective tissue the ground-substance of which has been hardened by the deposit of lime-salts, and in which the connective-tissue cells still persist, sometimes forming an integral part of the membranous constituents, sometimes scattered or arranged in the harder portions. As the health and life, or the disease and death, of ordinary yellow connective tissue depend on the action of these parts, so do the healthy and diseased nutrition of the ground-substance of bone depend upon the functional integrity or disturbance of the cellular elements, and of other cellular elements (migratory leucocytes) which may be added to them.

An inflammation of areolar tissue may have either formative or destructive qualities. It may tend to tissue formation, whereby the inflamed spot becomes both harder and larger, or, in other words, is swollen and indurated. Bone, being rigid, does not often swell by the interstitial deposit of new tissue-elements, but it frequently becomes extremely dense and heavy—osteosclerosis.[1] Areolar-tissue inflammation may, on the contrary, have destructive tendencies, viz., to suppuration and ulceration. So also bone-tissue, when inflamed, may undergo softening and rarefying processes (osteo-malacia, osteo-porosis), may ulcerate (caries), or may become gangrenous (necrosis) or phagedænic (caries necrotica). All these changes are induced by various acts of the cellular materials so richly implanted in that lime-bearing ground-substance which confers upon the structure its mechanical strength and rigidity.

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[1] My investigations and views on the process of inflammation in bones, and the points of difference in my views from those of Billroth, are set forth in my work on Diseases of the Joints.

[2] This view of the structure of bone might also be explained by pointing out the similarity, nay almost the identity of appearance of the ramified connective-tissue corpuscles of connective-tissue, and the ramified lacunar spaces of bone; if, for instance, we refer to two illustrations in Quain's Anatomy, we see there excellent representations of the former bodies; they also admirably portray the microscopic appearance of a thin portion, say a cancellar lamella, of bone; in solid bone as of a shaft, the elements are the same, only more regularly arranged.

The parts of bone, which for the present purpose are interesting to us, are the ends of long bones and certain short bones, as of the tarsus, which form integral parts of joints, which remain for many years of life in great part cartilaginous, and which afterwards become spongy or cancellous. The spongy texture is inclosed in a very thin case of bone, freely perforated by vessels, except on the surface which looks towards the joint.

Primary inflammation of the epiphyseal end of a long bone is uncommon in adult life, and, when it does occur, attacks by preference a small bone, such as a phalanx. Short articular bones, as of the carpus or tarsus, may be inflamed at any period of life, but also most commonly in youth—from eighteen to twenty-four; chronic idiopathic inflammation of the ends of the femur, tibia, or humerus is rare.[2] In young people, especially in children under ten years of age, the joint-ends of the large bones are very frequently the subject of strumous inflammation. The reasons of this proclivity at an early age are not far to seek: first, all strumous manifestations are most common in youth; and secondly, the great nutritive activity and ossifying processes at the epiphyses, accompanied by considerable hyperæmia, supply that slight irritation, to be responded to by prolonged inflammation, which supplies Billroth with his definition of strumous disease (see page 297).

The anatomical conditions are these: The bone-end or the short bone, as the case may be, is a mass of cartilage, in the midst of which is a growing osseous nucleus. On account of that growth the cartilage is very vascular, especially in the neighborhood of the nucleus. In most large joints the epiphyses are not fully ossified until about the age of puberty, and they retain their separation from, and their complete nutritive independence of, the shaft, for a much longer period.

When osteitis, or, as it is termed under these circumstances, epiphysitis, attacks a bone-end, whose nucleus, already cancellar,[3] nearly fills the whole space, the usual termination, in strumous children, is osteo-malacia and suppuration, with perhaps some necrosis. The focus of suppuration, unless diffuse, is frequently surrounded, or at least subtended, by an area of sclerosed bone, just as in soft parts a localized abscess is shut in by indurated tissue.

If an almost mature but inflamed epiphysis be cut across with a fine saw, the inflamed point, or, when the action extends over the whole structure, all the cut surface, will show either spots of redness or a uniform, red coloration, and from the opened cancelli will ooze a more or less opaque and milky fluid, partly consisting of medullary oil, and partly of a cell-charged serum which may not as yet deserve the name of pus. At a somewhat later period, the cancelli will be found stuffed with granulation-tissue, so tightly that it protrudes beyond and conceals the cut surface of the lamellæ. These latter become softer and thinner, and may in some place, larger or smaller, disappear, leaving in the worst and most advanced cases, instead of the normal, spongy bone-tissue, a mere soft mass of granulations, permeated by thin trabeculæ of softened bone, the remains of the lamellæ, deprived of lime-salts and rapidly disappearing.[1] In the new substance thus produced, and, as it were, substituting itself for the bony structure, many degenerations occur, as, for instance, spots of caseation, which, especially where vascularity is deficient, surround groups of giant-cells, a sort of change considered by some to be tuberculous. Fat, too, is often present in large quantities in the cells themselves, and lying diffused among them; pus also may be found, sometimes diffused, but more often gathered in little abscesses.

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[1] The enlargement of bone which is so frequently met with clinically, is, as a rule, due to deposit on the surface, but I think that the possibility of interstitial enlargement has been too dogmatically denied, as witness the condition, not very uncommon, called osteitis deformans. Moreover, I have had under observation for the last six months a child, aged 7, with very chronic osteitis of the tibia; the bone is not only larger than the other in circumference, but is also $1\frac{1}{4}$ inches longer.

[2] Arthritis deformans and the affections due to nerve-disease are excepted.

[3] The nucleus in earliest life is solid.

The fat above alluded to results from a degeneration occurring in granulations that have persisted for some time; this must not be confounded with a sort of osteitis peculiar to infantile life, in which the fattiness is primary, appearing to arise simultaneously with the inflammation. This fatty osteitis is at present little understood. Often in making a section of an inflamed epiphysis, the saw, the knife, and the hands, all become covered with oil. In attempting to obtain a lamella or section for the microscope, one finds all obscured by oil-globules, and frequent boiling in ether will hardly remove this redundancy of fat, with which not only the granulations but the bone-substance itself is soaked. In such conditions the cancellar plates are very thin, and are soft from deficiency of lime-salts, which I have no doubt have been dissolved slowly by oleic or margaric acid. Fatty osteitis appears to be somewhat antagonistic to suppuration, until a rather late stage; nevertheless, one occasionally finds an abscess in the midst of such disease, and subsequently the whole part involved may break into diffuse suppuration; but neither is found, as a rule, until the bone is quite softened, and, as a bone, almost destroyed. The subject is extremely obscure, but I think we may state as a fact that fatty osteitis, though occurring in strumous children, is never tuberculous, nor associated in any way with fatty degeneration, properly so called. It is singularly painless throughout its first stages; when suppuration occurs, it is rather widely spread throughout the bone-end.

If an osteitis, fatty or otherwise, of a short bone or of an epiphysis,[2] results in abscess, the pus, with the débris of inflamed tissues, or perhaps also with a sequestrum, will sooner or later tend to make its way towards a surface. If an abscess lies near to, travels towards, and opens into the joint, very evil, perhaps disastrous, consequences may follow. If it passes towards a lateral surface, the result will be much controlled by the relationship between the epiphyseal line and the capsule. In case the synovial membrane extends beyond that line, pus coming that way will, as in the former case, penetrate the joint; whereas, if the point towards which the abscess tends be outside the capsule, the joint may escape with little damage. So, also, when the abscess lies near and intrudes on the epiphyseal junction itself, much depends on the above point of its anatomy; but there is the additional possibility, if the pus be large in quantity, that loosening or separation of the epiphysis may likewise occur.

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[1] The mode in which the membrane lining the cancelli granulates, how the lacunar bone-cells proliferate, how these products soften the bone-tissues, first dissolving out the lime-salts by means, as I believe, of a fatty or, as Billroth thinks, of lactic acid, and afterwards permeating and absorbing into their substance the remaining fibrillated matrix, cannot properly be considered in this article. The whole matter has been fully discussed by Virchow (Cellular Pathologie), by Billroth (Chirurgische Pathologie und Therapie), by Volkmann (Sammlung klinischer Vortrage, and Langenbeck's Archiv, Bd. iv.), by myself (Diseases of the Joints), and by others.

[2] I am here speaking only of epiphyses which are matured, that is, in which the bone has already entirely or very nearly occupied the cartilaginous matrix, and has become cancellar.

Epiphysitis never reaches beyond the first stage without a certain invasion of the surrounding tissues, which become first œdematous and then thickened. Whether or no the cartilage itself increases in size, I am not able to say; it is, at all events, not impossible. After a time, an abscess outside the bone, independent of—that is, having no communication with the intraosseous abscess—may form, sometimes remaining close to the part (adjacent), sometimes reaching to a certain distance (neighboring). I am unable to account, to my own satisfaction, for a singular tendency which epiphysitis possesses to spread to the contiguous part of the opposite bone. For example, if the outer condyle of the femur be affected, the outer portion of the tibial tuberosity becomes after a time involved, and usually before the other side of the femoral epiphysis participates. Thus, also, inflammation spreads from one tarsal bone to another, so that we very rarely find one considerably inflamed without detecting, on anatomical examination, a like condition, but less advanced, in other contiguous bones. Such a phenomenon among smaller bones and joints is of course more easily accounted for.[1]

In epiphyses or in short bones, which are still quite immature, the inflammatory process is considerably modified, constituting what I have been in the habit of naming to my class "nuclear epiphysitis." In the earliest stage, the bony nucleus is alone hyperæmic, but afterwards the cartilage around it is also implicated; serum is effused between the one and the other, generally in spots here and there, sometimes more widely, and occasionally throughout. This fluid becomes, by the addition of leucocytes derived chiefly from the tissue-elements, turbid and milky, and slowly changes to pus. Extravasations of blood also take place in spots within the nucleus, or on the cartilage close to it. Where these effusions of fluid take place, the nucleus and the surrounding cartilage become separated from each other, the new surface of the latter being dendritic, rough, and generally vascular, while the shreds which hang from it float in the effused fluid. The nucleus itself becomes discolored, gray or greenish-gray, in small spots or in one large blotch; these spots generally break down into abscess-cavities. Either by conversion of the first effused serum into pus, or by suppuration of the newly formed bone, or by both processes, the nucleus is separated through a certain extent of its periphery from the surrounding cartilage. Sometimes, indeed, the whole osseous kernel is thus isolated, and when the cartilage is bisected, drops out of the cavity as a nut out of its shell.[2]

Now the pus thus lying in a cavity will not continue long to be quiescent. In one direction or another the cartilage becomes inflamed and ulcerates, and the abscess opens into the joint-cavity either by a large rent, or, as I think more often occurs, by a number of little channels. If this irruption of pus be almost sudden, violent synovitis, as in Mr. Brown's case,[3] or, if less explosive, a less violent but still acute joint-disease, ensues.[4] When, as more often happens, an intra-epiphyseal abscess passes more slowly toward the articulation, some inflamation of the joint-tissues precedes the irruption of pus; these are, therefore, no longer in the excitable condition natural to healthy synovial membrane, and resent the presence of pus but very slightly. Again, epiphysitis is often a remarkably slow affection, which, after months of more or less remittent pain, but of continuous swelling, may hardly reach beyond the stage of hyperæmia. It induces, however, by transmission through continuity, an equally chronic inflammation of periarticular and then of synovial tissues. The disease in these soft parts goes through the same processes as in strumous or fungating synovitis, but to him who will look for it, the point of origin will be quite apparent. If afterwards pus form in the bone-end, and ultimately break either into the altered joint or into the neighboring tissues, very little or no additional action is provoked by the occurrence. But that part of the cartilaginous epiphysis which lies next the joint, becomes more or less quickly disintegrated, the intra-epiphyseal inflammatory products mingling with those of the synovial tissues.

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[1] It is in great measure from tarsal bones which have been secondarily, and therefore less deeply involved, that I have been able to trace out the earlier phases of infantile epiphysitis.

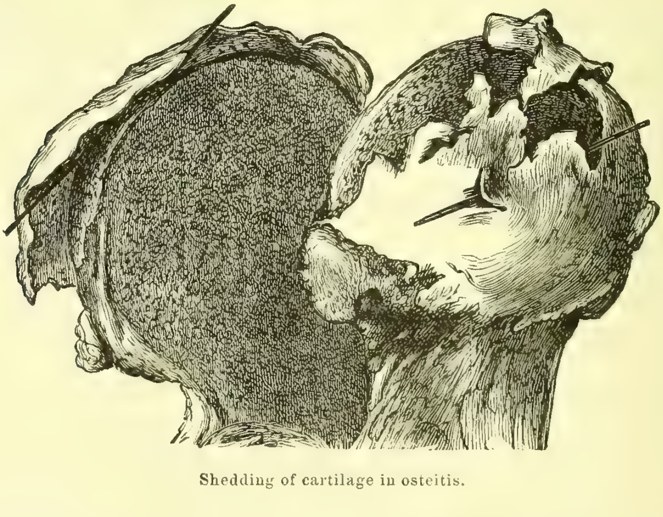
[2] Of course, to make these observations on separate cases of joint-malady would be impossible; a lifetime would not afford sufficient opportunities; but in the opposed joint-bones, and in the bones less advanced in tarsal disease, one finds examples of nuclear inflammation in all stages. In these I have discovered and traced out all the conditions above noted.

[3] Clinical Society's Transactions, vol. ix. p. 175.

[4] Mr. Smith, St. Bartholomew's Hospital Reports, vol. x. p. 190.

If the inflammation arise in an older person, in whom the epiphyseal ends are more matured, the articular cartilage yields by one of two processes, both of which are generally present in different parts of the diseased joint. One process, simply ulceration from the free surface, such as is described at page 304, occurs where the osteitis is at some distance from the articular facet, and where the inflammation has spread to the cartilage by way of the soft parts and the synovial membrane. The other process occurs where the bone-inflammation lies very close to the joint-surface, and after a time softens and destroys those lamellæ and trabeculæ which uphold the articular lamella; the cartilage and the gritty débris of that lamella then fall, or are pushed by subjacent granulations, into the more or less still persisting joint-cavity. Such pieces are often found lying in pus, or in new inflammatory tissue, with the sabulous detritus of the articular lamella still adhering on one side. If the inflammation and detachment have been rapid, the cartilage is quite healthy; if slower, it is in a certain stage of fatty degeneration. Thus, to recapitulate: Inflammation of an epiphysis, or of a short articular bone, culminating pretty rapidly in abscess with or without central necrosis, gives rise, when it passes quickly to the joint, to suppurative synovitis. When it passes to a lateral surface, it causes inflammation of the periarticular and synovial tissues of a subacute character, with extra-articular abscess, localized, or at least more severe, on one aspect of the joint. A slow epiphysitis,

Fig. 649.



Shedding of cartilage in osteitis.

with softening and intraosseous granulation, but either without abscess or with abscess of slow formation, is followed by a slow, fungous synovitis. The evident enlargement and change of form in the primarily affected bone-end marks the starting-point of the disease until it is far advanced.

When, however, the soft constituents of the joint and the other bones have been for a long time diseased, it not only is impossible, but also unnecessary, to distinguish the structure wherein the disease may have commenced; for at this late period, when granulation-tissue, abscesses, and other results of inflammation are found in the bone and the synovial tissues, equally diffused and equally active, the whole organ is reduced to exactly the same state as that which is left by a strumous synovitis, as already described (page 307).

When an epiphysis suffers from inflammation, its growth is arrested, such arrestation continuing even long after the disease has ceased. This result is the same whether the epiphysitis have been primary, as in the cases now under consideration, or secondary, as in synovitis, and whether the action have been suppurative, or have merely ended in sclerosis.[1] By these means the limb-growth, as far as it depends on the function of that particular epiphyseal junction, is checked: thus, if the child be quite young when the disease begins, and the arrest of growth last a considerable time, very considerable inequality of limbs results—an important matter in the lower extremities. I have lately had under my care a boy, aged 10 years, who, when four months old, suffered a fall upon the knee, which was much inflamed for some weeks, and the movements of which have been somewhat restricted ever since. The femoral condyles on the affected side look quite babyish in comparison with the others; they are:—

On the right, in breadth . .	$3\frac{3}{4}$	inches;	left .	$2\frac{7}{8}$	inches.
" " in circumference .	$12\frac{1}{4}$	"	" .	$10\frac{1}{8}$	"
Length of right limb . .	$27\frac{7}{8}$	"	" .	$26\frac{1}{4}$	"

A similar though not so marked a difference is the usual result of early epiphyseal disease.

Thus far we have confined our study of the disease in question entirely to local changes; but we must now go on to consider certain systemic conditions, and certain morbid changes of internal organs, which, either produced by the same diathesis or induced by the wasting effects of local malady, very frequently accompany the later stages of joint-disease.

Reasons have already been given (at page 297) for regarding certain low and very persistent inflammations as strumous. These inflammations tend to produce granulation-tissue of so sluggish a description that, though it may spread into and invade a large neighborhood, and disintegrate a large area of previously healthy structures, it does not tend to any higher organization, but rather to remain merely embryonic, with a proclivity to certain forms of degeneration. Among these are the fatty, always combined with or closely followed by suppuration,[2] and more rarely by caseation. Also, it is probable that in a certain number of cases tubercular degeneration occurs; but this condition is, I believe, far more rare than is commonly supposed. It is at the present day very much the fashion to speak of tubercular disease of bone as though it were a common condition, and yet crude, gray tubercle has not been found, as far as I know, in bone; and there is a vast difference between tubercle of bone and the tubercle of inflammatory products. It is, when as a rarity it occurs in this latter form, viz., as tuberculization of indolent granulations, that the so-called tubercular osteitis occurs. But great caution must be used before those non-vascular spots, formed by compressed endothelial cells surrounding two or more giant-cells, are accepted as tubercle, for all minute districts of granulation-tissue, which in their growth become deficient in vascularity, are apt to develop giant-cells, and these in their expansive growth starve and compress the endothelial cells lying in their immediate vicinity, thus producing a globular (on section a circular) envelope to the central large cells.

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[1] It appears that very slight inflammations may have this result; thus, we find occasionally a short limb that years ago had been hurt by a blow or fall, which laid the child on the couch for only a few days. There is, I think, reason to believe that a chronic inflammation of the diaphysis tends rather to lengthening.

[2] I must recall to the reader's memory the distinction between fatty degeneration of old granulations and primarily fatty osteitis.

But the strumous is very closely related to the tuberculous diathesis, and it is only too common to find that patients suffering from strumous joint-maladies will, after a time, develop tubercle of the cerebral meninges or of the lungs. Such a sequence may be interpreted in one of two ways: The first, that a given patient is affected with struma, and therefore is prone to a closely allied disease, and that by a wearing and exhausting joint-affection the patient has been reduced to a condition especially favorable to the production of tubercle. The second, that a certain bacillus has produced the primary tubercle, and that its spores are afterwards transported from its original site to the lung or the membranes of the brain. The former of these interpretations is a view which has been common in the profession for very many years, and nothing material is here to be added on the subject. The latter encounters many difficulties. No peculiar bacillus has, as far as I know, been discovered in tubercular organs to which air has no access; and it would be very difficult to imagine—probably impossible to prove—that a development of tubercle in one part could call forth tubercle in another not directly connected with it by circulation, lymphatic or sanguineous; but there is no difficulty in seeing that the constitution which develops tubercular deposit may do so at two places simultaneously or consecutively; or, indeed—and this lies nearer to my views—that the diathesis which produces strumous malady in structures not prone to tuberculosis, may cause tubercle in organs prone to that deposit. In other words, there is at present no proof of infection from person to person, nor from one organ to another and a distant organ; but there is plentiful proof of constitutional and hereditary tendency to certain forms of disease. Hereditary tendency is a characteristic entirely different from what we know of diseases produced by bacilli or microzymes.[1]

The fatty and suppurative degeneration of inflammatory tissues, if extensive and long continued, leads to a morbid condition of certain abdominal organs—liver, spleen and kidneys—often called amyloid, a term which should be forgotten, but better named lardaceous. This change, being a sequela of long-continued suppuration, when large in quantity is more apt to follow on suppuration of bony tissues, which is always prolonged, than on that of soft parts, which is usually less enduring. Dr. Wilks and Dr. Grainger Stewart[2] both associate it with deep-seated cachexia, such as is produced by strumous or syphilitic disease, particularly if it affect the bones, and it further appears to be owing, as Dr. Howship Dickinson[3] has shown, to a diminished alkalinity of the blood, produced by draining away of certain salts with the pus; a chemical but rather barren report[1] shows, in respect to the liver, that the lardaceous organs "are considerably deficient in potassa and phosphoric acid, while they contain an increase of soda, chlorine, and cholesterine;" and "that the deposit producing the peculiar condition may be called *albuminoid*, although the proportion of nitrogen it was found to contain appeared to be somewhat lower than that which exists in albumen."

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[1] At page 299 *et seq.*, some account was given of Dr. Schüller's experiments in injecting various tubercular—or supposed tubercular—materials into the blood of animals in whom a knee-joint had been severely injured; the experiments seem to prove that the joints are hardly to be rendered tuberculous by any such process. At the same time some doubt was indicated as to the truly tubercular character of all the aniline-dyed bacilli found in sputa, or in the pus of phthisical cavities. Those paragraphs were written, as was the text above, before the appearance of Dr. Spina's researches and of his excellent criticism of Dr. Koch's work. To these I would refer the reader.

[2] Guy's Hospital Reports, 1864 and 1865.

[3] Med.-Chir. Trans., vol. l. p. 39. 1867.

This albuminoid matter is deposited in various parts of the different organs named, chiefly along the course of the minuter vessels, and therefore especially where function is most actively carried on. For instance, in the Malpighian bodies and the tubuli of the kidney; in the lobules of the liver, intermingling with the hepatic cells; in the Malpighian corpuscles of the spleen. Hence, it early interferes with, and, after a time, abolishes, the function of the particular glandular element in which the deposition occurs;[2] the effects therefore produced vary according to the organ attacked. Often, however, two of those named, and less frequently all, are involved; yet whether one or more be thus diseased, mal-nutrition, cachexia, and increasing anæmia are the invariable results.

Special note must be taken, however, of the effects produced on the secretion of the kidneys by this disease, viz: albuminuria, and the appearance in the sediment of certain casts called hyaline, which consist of a very transparent, highly refracting material, often lined externally with an imperfect covering of epithelium, which, having adhered to the "*albuminoid*" cast, has become detached from the tubule, the lining of which it really is.

Nevertheless, it must not be assumed that these changes are, unless they have overpassed a certain point, necessarily fatal; if suppuration, the cause of this disease, can be summarily stopped, lardaceous changes will retrograde, even rapidly, if the patient be still young.

SYMPTOMS.—The joint-ends of long bones are in adults rarely inflamed. When thus affected, the disease is generally rheumatic or traumatic. Syphilitic osteitis usually attacks the shaft. Short bones, as those of the carpus or tarsus, as also the ends of phalanges, may be inflamed in adult, and even in senile, life.

The first symptom in articular osteitis is a dull, heavy pain, which is worse at night. In young children this symptom is translated into limping, and disinclination to move the limb; also into sleeplessness or restless sleep, with waking up to cry. On examination, no change may be perceptible to the eye, and it may be difficult at first to ascertain which is the affected joint;[3] but care in examination will eliminate error. Palpation of the affected part will discover a certain change, hardly as yet an enlargement, of one bone constituting the joint; for instance, at the knee, accurate comparison with its sound fellow will verify a slight swelling of the deepest soft parts, beneath which the bone will be found, not increased in size, but altered by a subtle change of form; the normal depressions being less marked, and the elevations not so prominent, but broader.

After a time, the enlargement becomes more real, and perceptible to the eye, but is still confined to one part of the joint, or rather a little above or below the actual joint; that is, the place where the two bones are in contact. There are about that part one or two places where tenderness may be found, and perhaps some obscure fluctuation, often false, may be detected. All this time, and the condition may remain almost unchanged for months, the joint itself, that is, the synovial membrane and cartilages, will be quite healthy, and if the osteitis be cured, no articular immobility will result. It is advisable that the surgeon should measure the different parts of the joint; the tape often gives no information, but a pair of small callipers, easily carried in the pocket, will greatly help him in verifying the increase of size, let us say, of one condyle, of a part of the tibial tuberosity, of the lower end of the ulna, etc. Moreover, the instrument will tell him if one part only of the joint-end be enlarged. To exemplify the method of using this instrument, let it be assumed that the inner femoral condyle is the suspected part; the first measurement may be across the whole lower end of the bone (that is, from the outer face of the external, to the inner aspect of the internal condyle); if this be found larger than the corresponding part on the other limb, the condyle itself can be compared with its fellow by measuring, first, from close to the inner edge of the patella to a point just inside the inner margin of the semi-membranosus muscle; and secondly, from above downward, viz., when the knee is bent at right angles, from a spot just in front of the insertion of the adductor magnus, to the angle where the inner, non-articular face becomes the horizontal joint-facet. A source of fallacy may be presented by a certain tumefaction of the soft parts, but an educated touch will be able to estimate the amount of this thickening, and subtract it from the difference given by comparison of the diseased with the sound limb. By these or similar means, at other joints, a fairly accurate judgment as to the reality and amount of bony enlargement may be obtained.

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[1] Transactions of Pathological Society, vol. xxii. pp. 1–12. London, 1871.

[2] In regard to the liver, fatty are very frequently, though by no means always, mingled with lardaceous changes.

[3] Students and young practitioners are so often cautioned against attributing the knee-pain of hip-disease to a malady of the knee, that the contrary error sometimes occurs, and I have more than once known treatment to be directed to the hip, when after-events showed that a femoral condyle was the affected part.

About this period of the disease, the skin over the affected part assumes a peculiar aspect; it is white, looks as if tightened over the underlying parts, and has a lifeless or bloodless appearance. The swelling is not by any means sufficient to produce stretching, and, unless the condition be caused by derivation of blood from the superficies, or by some condition of nervous supply, I know not how to account for the phenomenon.

After an interval, the skin over the affected part becomes reddened, generally intermittingly; at first it often pits slightly on prolonged pressure; a point may even appear to fluctuate, and this usually indicates that the osteitis is very near that particular spot. At this stage, muscular phenomena (contraction followed by contracture) usually set in, and starting pains are soon after added. The time when these symptoms commence is quite uncertain; it depends on the proximity of the abscess to the articular facet. It may be that the neuro-muscular phenomena precede any implication of the synovial membrane, or any redness of skin, or they may come after such affection has commenced; but under either condition, they are, in respect to the synovial disease, very early; that is to say, when disease has commenced in the synovial membrane, greater morbid changes of that tissue take place before starting occurs than when disease commences in the bone. Also, in many cases, subluxation slowly sets in much sooner than it does in mere synovial malady. However slowly the perisynovial tissues respond to the inflammation, they do, after a time, unless the epiphysitis cease, reply by a process of proliferation and granulation, whereby the whole membrane becomes thickened and enlarged. Pus may be formed in the joint and in the extra-articular tissues, even before intraosseous abscess has opened in either direction; thus the symptoms of granulating synovitis are superadded to those above described, but nevertheless they are not quite like those produced by disease primarily synovial, for the enlargement of the periosteal and osseous tissues at the original site of the malady still marks the pre-eminence of osseous disease; the greater preponderance of neuro-muscular phenomena also plainly indicates the true nature of the malady.

When the osseous wall gives way outward, and the inflammatory products mingle with those already in the soft parts, abscesses, either deep or approaching the surface, give their characteristic fluctuation, while the skin reddens over those which are superficial. But if the bone cavities open into the already granulating and suppurating joint, no definite change of symptoms marks the occurrence. Occasionally the intraosseous disease is quickened, and a central necrosis, or an abscess without necrosis, forms in the epiphysis, and may with more or less rapidity pass towards a surface; the approach of the inflammation or abscess towards some bone surface other than the articular, is heralded by a spot of persistent tenderness on pressure, as well as by redness, while the subjacent tissues are swollen, soft, and boggy. A still nearer approximation is marked by pitting, and afterwards by obscure fluctuation. If the inflammation or its products extend towards the joint, hitherto but little affected, marked exacerbation of the articular swelling, much fluid in the cavity, increased pain, and especially more violent starting pains, will denote the time of its coming near to the cartilage. The actual entry of pus into the cavity will give rise to no symptoms if the joint be already considerably inflamed; indeed, since intraosseous pressure is relieved by the discharge of matter, some of the most distressing symptoms will for a time subside. After forty-eight hours, however, there will supervene, if much pus have entered the joint, a peculiar appearance of the part. The skin becomes swollen and sodden-looking, with superficial pitting; it is very white, save in one or two broad wavy lines, or in foliaceous pink patches. Such a joint is much influenced by the pressure of the limb's weight, so that as it lies on the splint or cushion it is flattened on its upper and lower aspects, and broadened out at the sides. The patient's health is much depressed; he is weak, hectic, and pale, with a white, sodden tongue. The thermometer is but little above normal in the morning, but rises two or more degrees in the late afternoon and evening.

Certain cases present symptoms which are rather enigmatical to the practitioner who is not considerably versed in this class of diseases. The patient may have had considerable pain in a bone-end, and some slight swelling of the soft parts over it, combined with stiffness of the joint, restless nights (waking and crying out, if a child), starting pains, and evidence of pain on moving, or, at least, disinclination to move the joint. But with all this there may be no articular swelling, save the spot over the bone-end above mentioned. Suddenly, or all but suddenly, this condition will be unpleasantly interpreted by the appearance of a violent synovitis, which, if not at first suppurative, very soon becomes so.[1] The symptoms denote that the osteitis has begun very near the joint surface; perhaps that necrosis has even involved the articular lamella; that the cartilage has suddenly given way, and that pus, with other inflammatory matters, has been poured into the joint.

The slow form of disease first depicted, and also the latter, more rapid malady, if the first violence be overpassed, leave the soft and hard constituents of the joint granulating and suppurating; abscesses open to the surface, and sinus-mouths, crowned with large granulations, perforate the skin. These sinuses and abscesses differ a good deal in their appearance, according as the osseous disease is a caries or a necrosis. In the case of *caries*, the pus is thin, irritating, and copious; the sinus-mouth, some distance from the seat of disease, is crowned by large florid granulations, of a peculiarly brilliant color, and bleeding very easily; the skin around is tightly drawn, of a bluish shade, and looks thin; the sinus is tortuous, whence there may be difficulty in touching the diseased surface with a probe, and when the carious surface is touched, a fresh flow of blood ensues. When the disease is *necrosis*, the pus, not large in quantity, is nearly laudable; the granulations surrounding the sinus-mouth are large, flabby, and not very brilliant, and do not bleed with extreme readiness; the skin around is normal; the sinus is short and fairly straight; the diseased bone does not bleed on contact with the probe. A peculiarity of the abscess-openings in children, which is, I believe, due to the slow formation of pus, and which I have been accustomed to connect with fatty osteitis, is detachment of the skin for a long distance around the opening. The same thing occurs to the skin over suppurating tubercular glands of the neck. One may pass a probe introduced through an opening of, for instance, $\frac{1}{4}$ inch circumference, and let it travel under the greatly thinned skin in a circle extending on all sides from $\frac{1}{2}$ to $\frac{3}{4}$ inch away from the margin of the wound. This skin, detached from subjacent parts, continues to get thinner, until it becomes perforated with little pin-hole openings; and ultimately it may give way altogether. But the skin over the abscesses of fatty osteitis does not become discolored for a long time; that over tuberculous glands is reddened much sooner.

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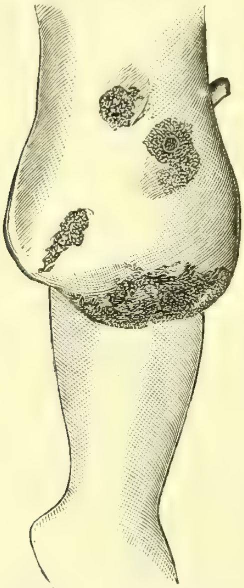
[1] For symptoms see p. 282.

Fig. 650.



Osteal joint-disease; epiphysitis affecting whole lower end of femur; caries.

Now, the joint which has become diseased by way of the bones, and by secondary affection of the synovial membrane, comes in this stage to be in the same state as one which, having been the seat of synovial disease, has now also involved the bones; and the one malady, like the other, may tend either to further destruction or may retrograde. The signs and symptoms of either course are identical with those described at page 312 *et seq.* With them are combined certain alterations in and dangers to internal organs, and thus to life; but as long as these remain absent, the joint-trouble in itself does not kill; and even after severe local ravages all morbid action may cease, leaving not disease, but the results of disease, behind. There is no doubt that a vast number of persons recover from very severe joint-affections. In institutions with which I am connected, many inmates are under my supervision with one, sometimes with two, limbs scored with old abscess-scars, very numerous, near to and distant from the marred and generally anchylosed joint, and indicating an amount of past disease which I, without such experience, and influenced only by what I see in hospital, should have thought could hardly be survived. The moral is instructive, and will be again referred to very shortly. But the surgeon must not be content with considering the joint alone; he must frequently go further, and examine into the state of lungs, liver, spleen, and kidneys, to detect the earliest signs of tubercular or of lardaceous disease. To the surgeon experienced in these matters, additional morning and evening irregularity of the temperature, night-sweating, a red flush on the cheek (often only on one), bounded by a clear defined edge, evening cough, and morning expectoration, will indicate the *lung* as the special seat of danger.

The symptoms of nascent *lardaceous disease* are very much more obscure; they, of course, vary with the organ attacked. The one symptom common to all, is increased loss of health, visible cachexia, and considerable wasting. If the *liver* be affected, to this must be added an icteroid tinge, but not jaundice, with occasional constipation varied by colliquative diarrhœa, clay-colored and highly offensive evacuations, and a manifest increase in the size of the organ, the margin of which is evident far below the ribs. The symptoms of *splenic* affection are more obscure, but a certain yellowish-brown or clayey change in the complexion, together with a dry, rough, furfuraceous skin, a peculiar pallor, and slight yellowness (a maple-yellow, not the almond-orange tint of jaundice) may lead to the suspicion that the spleen is implicated. It is not usual that any enlargement can be detected until late in the disease. Lardaceous changes in the *kidneys* are detected with ease and certainty; they lead rapidly to one form of albuminuria, which, however, in and by itself is not diagnostic; but by placing some of the sediment under a sufficient power of the microscope, hyaline casts are readily detected. These bodies are so peculiar that he who has once seen them can never mistake any other object for them. They have the form of the *tubuli uriniferi*, and generally on the surface, here and there, are either epithelial scales or the mouldings of their lines of separation; they are, and by this they will chiefly be recognized, highly refracting. Naturally, they are somewhat various as to size, according as they come from the larger tubules near the hilus, or from the smaller ones close to the cortex, and from the neighborhood of the Malpighian tufts. When in albuminous urine such casts are found, it may be concluded that the albuminuria is due to lardaceous change; but I have some reason to believe that a kidney already advanced in desquamative nephritis may subsequently become lardaceous. This observation may be important in certain cases.

Treatment.—In the early stage of chronic articular osteitis, the same general treatment may be used as that recommended for strumous synovitis. Tonics and judiciously-adopted alteratives have certainly their advantage. Among these, movement of the sound limbs and exercise in the open air play a large part. Even when, on physical examination, enlargement of the bone-end only can be detected, and while yet the soft tissues of the joint are free from swelling, rest of the part must be enforced; and if the disease affect the lower extremity, a splint which fixes the diseased joint and leaves the other free, is to be applied and maintained in position both day and night,[1] the patient being encouraged to remain in the open air and take as much exercise as possible. In the mean time, blisters, allowed to remain on the limb a little longer than in fungating synovitis, but allowed to heal at once, and frequently repeated, are very valuable. In some cases benefit appears to result from the actual cautery, the iron being drawn in one thin line across the inflamed spot. The skin on each side of the intended line should be well protected with two or three layers of wet adhesive plaster. A Paquelin's thermo-cautery, heated to whiteness, is the best instrument. After cautious removal of the plaster, the burn should be dusted with flour or oxide of zinc, and covered with cotton-wool. The burn thus made is singularly painless; indeed, if joint-pain be pretty severe, and especially if there be starting, great relief is obtained. The disappointing part of the method is, that in many cases, after the immediate inflammation of the skin-burn has ceased, the symptoms are apt to recur; the inconvenient part is the presence of the sore and subsequent scar. In certain cases the treatment is certainly useful; the difficulty is to distinguish these cases beforehand. It appears to me that those cases benefit most which are marked by severe starting pains before any synovial disease begins, and which show an early tendency to intraosseous suppuration.

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[1] The sorts of splint advised are described and depicted at page 316 *et seq.*

The oleate of mercury, 5, 10, or 20 per cent., according to the age of the child, may be painted on the swollen part every day, or every other day, so as slightly to redden the skin; the iodide of potassium ointment, or strapping with the plaster of mercury and ammoniacum, or of iodide of lead, may be employed. Pressure is of little, probably of no use, but somewhat powerful counter-irritation, such as may tend to direct hyperæmia to the skin, appears to divert it from and so relieve the bone. The great necessity of treatment, however, is to keep the joint at rest, to prevent either weight or muscular pressure, and to do this by some means that will allow to the child exercise and plenty of fresh air.

If in spite of these measures the joint-end continues to be inflamed—if it swell more, and especially if it assume somewhat of a conical form, while starting pains supervene, or, if they be already present, increase—we may conclude that the intraosseous or intracartilaginous parts are in a state of tension, are very possibly progressing towards suppuration, or have already begun to suppurate. Under these circumstances, it evidently becomes the surgeon's duty not to wait upon events, nor let the pus choose its road, perhaps into the joint, or otherwise into dangerous parts; but he should take the initiative, and by opening the outer case of cartilage or bone, guide the diseased products in a safe course. In considering the application of this method, the surgeon must of course be well aware that, even though the symptoms may indicate a certain point for perforation, he yet may not find an abscess, occasionally, no doubt, because none is present, and occasionally, because though present, it has been missed.[1] By having pierced the bone, however, even when no abscess exists, benefit and not injury results; the signs which the surgeon has before him indicate intraosseous pressure, and it is only a little more or a little less gravity of the symptoms that can indicate whether that condition is due to the presence of pus, or of effused serum, or merely to hyperæmia. In either event, the relief by what I have termed "paracentesis ossium," relieves that pressure which otherwise would result in suppuration, perhaps in necrosis. To perforate and miss an abscess is a mischance, which the surgeon must do all in his power to avoid; the result is not direct injury, but absence of expected benefit to the full extent desired; nevertheless, some diminution of tension is produced, and I have twice seen abscesses that had been missed, open in five and eight days respectively into the perforation. Means whereby the mishap may as much as possible be prevented will be described immediately. When, therefore, the symptoms indicate intra-epiphyseal tension, the surgeon has to ask himself if they are sufficiently decisive to call for interference; and, if so, whether the spot most clearly marked be in such a situation as to be attainable without injury to the synovial membrane, even though he may have to make the paracentesis somewhat oblique. If the patient be so young that the epiphysis or short bone is chiefly cartilaginous, a tender, swollen, and red point of skin, when such appears, marks a spot opposite the site of chief intra-epiphyseal disease; if subsequently, or in more acute cases, the whole neighborhood be red and swollen, it may safely be concluded that all the nucleus opposite that side of the limb is inflamed. Thus in either case it is impossible—given an accurate knowledge of infantile anatomy—to miss the nucleus and the seat of tension. But if general swelling of the epiphysis, with the other signs of tension, be unaccompanied by any distinctive change in the condition of the skin, operation is the more imperative; since the disease is, in all probability, extending either towards the joint or towards the epiphyseal junction, the former direction being the more usual.

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[1] Holmes, Surgical Treatment of Children's Diseases, p. 427.

Having determined to operate, the surgeon, bearing well in mind the line of attachment of the synovial membrane, makes beyond that territory a crucial or **T** incision down to the bone, from which he peels the periosteum with a raspatory. (This, however, if the part be still cartilaginous, is usually impossible.) The flaps being retracted, he introduces the head of a small trephine, and removes to such depth as he may consider sufficient, a plug of the bone, which is carefully to be examined for any softening, induration, or such new surface as may be the wall of an abscess cavity. The opening, too, must be carefully watched for any outflow of pus; if this come freely, the cavity, although it probably has been sufficiently opened, should be examined, since another cavity may exist, or since a sequestrum may require removal. If only an oozing of pus or serum occur, a probe should be used to find the situation and direction of any channel. If no morbid fluid escape, exploration must be carried further. I have found the best instrument for this purpose to be a rather fine and well-tempered brad-awl, which may be used with simply a thrust, or, if necessary, in the usual way by rotation. It may be passed from the original perforation in various directions, being carefully watched for signs of pus, and from time to time withdrawn, that the fluids adhering to it may be examined; any abnormally hard part of bone is to be suspected, since localized abscess is very usually surrounded by osteo-sclerosis. Any softened portion must be gouged away, or otherwise removed.

If the epiphysis be still quite immature, the best instrument for perforating the cartilage is a gouge of suitable size, whose side edge also is sharp for $\frac{1}{3}$ or $\frac{1}{2}$ an inch; a plug of the cartilage down to the osseous kernel is easily removed with this instrument. The condition of the escaping fluid, if any, must be noted; the nucleus is to be examined with the probe, and any softened or otherwise diseased portion removed; sometimes even it is necessary to take away a very considerable part, and occasionally I have removed the whole as a sequestrum. Mr. Eve, indeed, recommends that in all cases the inner parts of considerably-inflamed epiphyses should be removed after the manner called "*évidement des os*," leaving, that is to say, only the outer shell.[1] I have not found this to be necessary, unless the whole be either necrosed or carious; removal of the parts which are in that condition, together with relief of tension, is sufficient to allow the rest to recover.

After the operation the wound is to be well mopped out and cleansed with an antiseptic—boroglyceride is preferable to carbolic acid, which is too irritating, and is of itself enough to set up some osteitis—when a drainage-tube, big enough to fill the perforation, is introduced to the depths of the wound and there retained. I prefer to syringe through it, and leave it *in situ* until it is pushed out by the granulations which in a few days arise in the bone, and which, if the disease have been efficiently removed, fill the cavity in from a fortnight to six weeks, according to its size.

While wishing to avoid any exaggeration, I must be allowed to state from my experience that many cases thus treated get well, which, if left alone, would, according to all appearances, result in very severe disease, with all its dangers and evil consequences.

But a certain number of cases, although undoubtedly osteitic, do not show such signs of tension as would induce most surgeons to perform paracentesis,[1] and some few cases, in spite of the operation, still progress badly; this occurs chiefly when delay has been prolonged until the soft parts of the joint have become diseased, or else when the osteitis has been unfortunately situated close to the articular facet. When such continued disease, from whatever cause, occurs, the treatment resolves itself for a time into the maintenance of rest and of good position, while, unless the limb be too painful, exercise in the open air is enforced.

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[1] British Med. Journal, vol. ii. 1882.

An abscess near the joint should be treated as soon as it is plainly detected, and best by free incision; a probe or a finger may then be passed into the cavity, and an examination made. A circumscribed caries, if accessible, may be dealt with by the gouge; a sequestrum of similar character may be removed, even although not yet loose, if it be within reach of the instrument. If a part of it constitute some large portion of the joint-surface, I would the more insist on this practice, as affording freer exit to intraosseous pus and allowing earlier anchylosis, which, for a joint thus involved, is the best means of cure.

In all other points, save that of ascertaining and thus actively treating the condition of the bone, the management of the latter stages of articular osteitis and of strumous synovitis are alike, and I would refer for details to page 314 *et seq.;* but it must be noted that the prognosis of articular disease commencing in the bone is, even in these late stages, worse than that of disease primarily synovial.

If the osteitis have attacked one or more small bones, such as those of the carpus or tarsus, a device for removing the débris of *caries necrotica* may be employed, and sometimes with excellent results. In such cases, abscesses will have resulted in leaving either on one or both sides of the part, one or more sinuses, into which a probe being passed, impinges on carious or necrotic bone. The gouge is not as efficacious here as with joint-bones of larger size; but a mesh of prepared tow, oakum, or tenax, may be drawn through the diseased parts, only taking care to wound no important vessel or nerve, and to secure, where the fabric passes through the skin, openings wide enough to let the mesh lie quite loose and free. Every few days the big tenax seton is drawn a little through; in a short time it entangles and brings away larger or smaller pieces of bone detritus, and after a time, when all have been removed, healthy granulations arise from the sound bone left behind. In carrying out this method, it is very important to pass a seton along each and every diseased track, and to leave it in place until all the carious bone is removed, as otherwise the morbid condition will recur. During this treatment, one of the splints already described—and, to my mind, Dumbrowski's is the best—is to be applied, and the patient is to be allowed to go about.

If suppuration, with caries or necrosis, still persist, the surgeon has several very difficult problems wherewith to deal, depending upon the condition of general health and of the internal organs; he must frequently examine the lungs, and ascertain the presence or absence of cough, hectic, night-sweating, etc.; the size and condition of the liver and spleen must be constantly inquired into; and the urine must be from time to time examined for albumen and hyaline casts.[2] If this examination afford no ground for anxiety, a careful estimate must be made of the tendency to get well, or of the possibility of inducing such a tendency, as also of the probable condition of the limb which may be left behind, when, the disease being overpassed, healing has been completed. Upon the data thus gathered must be founded the decision as to the advisability of amputation or excision.

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[1] I resort to the operation whenever epiphyseal swelling is marked and starting pains commence early.

[2] See pp. 361 and 365.

But if, on the contrary, the examination reveal commencing lung mischief, a very careful estimate of its stage, and of the possibility of its retrocession, must be formed. A certain, possibly only a small amount of bronchial or perilobular change can undoubtedly be repaired if the source of suppuration be at once eliminated. Conclusive signs of tuberculization, and *a fortiori* of the existence of cavities, would of course debar us from any operative measures.

In regard to lardaceous disease of abdominal organs, I am able to speak very positively, for several cases have shown me that a liver, even so enlarged that its edge lies below the level of the umbilicus, will recede when the flow of pus is at once prevented; even a spleen large enough to reach half-way to the middle line will diminish under the same circumstances. In order to appreciate the state of the kidneys, examination of its secretion should be made on three or four consecutive days. If all the casts be of the largest size—if there be absolutely none of the smaller sizes (and several specimens should on each occasion be examined[1])—and if the albumen in the test-glass do not amount to more than one-quarter of the depth of the fluid, we may operate with fair hopes of success.

But these remarks apply only to young patients; to those under twenty-five, still more to those under fourteen. Moreover, they take for their basis the postulate that suppuration can be at once stopped; hence, for such cases amputation is the one operation to be advised, and excision is as a very general rule inadmissible.

III. Arthritis Deformans.

This name is preferable to rheumatic gout, or chronic rheumatic arthritis, because it does not imply a pathological relationship, which is by no means proven; the term "rheumatoid arthritis" may be less objectionable, because the disease is in some of its symptoms—but only in some, and not in its anatomy—a little like rheumatism.

The disease chiefly attacks elderly people, though occasionally exceptions to this rule occur, which are traceable to some febrile disease, or, and these are the most frequent exceptions, to a disturbance or suppression of the catamenia. It has a considerable predilection for the male sex, and is most common among the poorer classes, who are badly fed, and much exposed to vicissitudes of weather.[2] It is generally multarticular, but not infrequently uniarticular, and then it usually attacks the hip-joints of old men. The malady, then commonly called "morbus coxæ senilis," has frequently a traumatic causation. Some of the patients are prematurely old, depressed in health, and feeble; others are rosy and cheerful, with excellent appetite, and with quiet sleep. In some, the urine deposits plentiful lithates; in others, though the fluid is too acid, no such deposit takes place. Some persons are attacked at a perfectly definite moment of time, and the malady runs pretty quickly up to a certain not very advanced point, the further steps being slow. In other persons it commences very insidiously, and its progress from the very commencement is quite gradual. Again, in certain patients, the periarticular tissues (to judge by symptoms only) seem for a long time the only parts affected; in others, the proper constituents of the joints become earlier involved.

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[1] The smallest casts sink, as a rule, quickest, and lie at the lowest part of the sediment.

[2] Haygarth, the first who noticed this disease (Nodosity of Joints. London, 1805), made a directly contrary statement, namely, that it most commonly attacked women of the wealthier class. Brodie described it as very prone to attack the little-worked and over-fed upper servants of great houses; he evidently did not properly distinguish the malady from true gout.

Morbid Anatomy.—From the last sentence it may be gathered that all parts of and around the joints are concerned in the disease; and certainly this is the case, although the most marked and conspicuous changes fall upon the bones. Given succinctly, the alterations of the different tissues may be thus described:—

Changes in the Peri-synovial Tissues, Ligaments, and Tendons.—The first two are in the beginning simply inflamed and thickened, and the disease may, as above indicated, remain for a long time confined, or almost confined, to these parts. As time goes on, the thickening increases and induration occurs, the tissue being converted into a material like coarse fibro-cartilage. In other parts of the same tissue, the contrary effect, namely, considerable thinning and absorption occur. The difference appears to depend upon whether the particular part is relaxed or kept on the stretch. Afterwards the thickened part becomes in many cases ossified, not merely calcified; true bone, though rather imperfect, is formed, usually beginning at the line where the fibrous capsule is attached to the bone, and spreading thence in an arborescent or foliaceous manner, sometimes in blotches or plates. Occasionally, even nearly the whole tissue may thus be converted into a sheath of bone. In tendons and their appendages the chief changes fall upon the synovial sheath, the inner surface of which becomes coated with a fine dendritic growth, which gives it a velvety or fur-like aspect.

The synovial membrane is at first red, from hyperæmia, but afterwards paler, because the vessels are much concealed by thickened tissue. Around its osseous attachment, very coarse fringe-hypertrophy is strongly marked. The growths are at first thick and strong, and are clubbed at the ends by the development of nodules, some of which have passed through the stage of cartilage and have become bone.[1] As these bodies increase in size, the fringe attaching them becomes thinner, and forms at last a mere thin thread. When the bony plates in the capsule are well developed and thick, some of them press on the membrane, and, after a time causing its absorption, protrude through it, so that they form at last part of the boundary wall of the joint. During this hyperplasia, the tendons or ligaments that lie within the joint, *e.g.*, the long tendon of the biceps, the round ligament of the hip, the crucial ligaments of the knee, partake in the same condition; their interfibrillar constituents proliferate, separate the fibres, and afterwards more or less absorb them; they become detached, first at one end, the ligamentum teres from the digital fossa, the cross ligaments, as a rule, from the tibia. When the intra-synovial part of the bicipital tendon is absorbed, it gains a fresh attachment in the bicipital groove lower down, unless prevented by large osseous changes to be hereafter described.

In the *cartilages* the changes are very peculiar and multiform: hypertrophy, atrophy, ossification, fibrillation, and fatty degeneration. The localization of these different pathological acts to different parts is as follows: where there is no or but little mutual pressure, hypertrophy takes place; where the pressure is considerable, there is atrophy. Thus, the edges of cartilages grow out in the direction of their surface, or, as we might say, centrifugally. For example, at the head of the femur the edge of the incrusting cartilage grows from the edge of the half sphere towards the trochanters, so that if this prolongation were perfect and uninterrupted, the added cartilage would form a tube surrounding the neck of the bone,[1] while a similar outgrowth from the edge of the acetabulum would inclose that tube in yet another one. This growth at the edge of cartilages may be termed marginal hyperplasia; the outgrowths rapidly ossify. But mingled with this process, lines and intersections of fatty degeneration and atrophy occur, in such wise as to divide the added parts into irregular masses of somewhat square, hexagonal, or rounded shape, which thus come to form nodosities, or larger craggy conglomerations about the margins and surroundings of the joint ("additamentary bones").

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[1] See the sections on Hydrarthrus, and on Loose Bodies in Joints.

But in the mean time, wherever pressure occurs, atrophy of the cartilage prevails; in some parts by fatty degeneration of the cells, enormous exaggeration of the corpuscles, and peculiar, coarse fibrillation of the hyaline substance. In other parts, the cartilage seems to disappear simply by encroachment of the bone from the deep surface. The outcome of these difficult and complicated changes is, however, quite simple, viz., disappearance of the articular cartilage; the bone is left bare, while by the marginal hyperplasia the amount of contact-surface is largely increased.

The *bones* undergo very remarkable changes of constitution and of form, produced by an intermixture of hypertrophy and of atrophy. Both these actions are of two sorts—interstitial and dimensional—producing respectively condensation or rarefaction, and increase or decrease of size. The combination of these two acts is influenced by pressure-friction, which produces by its irritant effect interstitial hypertrophy, and by its wearing effect dimensional atrophy. In other words, all hardened or condensed portions are undergoing "*usure*" or wasting, while all outgrowths and dimensional enlargements are at the same time rarefied. The former are all situated where the juxtaposed bones press and rub on each other; the latter on the margins of articular surfaces where no pressure exists, until the outgrowths from the different bones come into contact.

This sort of induration is not quite the same thing as an osteo-sclerosis, produced by an ordinary osteitis, and consisting of an orderly increase of the bone elements within a given space. The induration of arthritis deformans is, on the contrary, produced by the deposit of lowly organized bone-salts, in the form of an effusion among, rather than of assimilation into, the bone-tissue imparting to the structure an appearance like porcelain, whence the name "porcellanous deposit." Mr. Quekett long ago pointed out the mechanism of this change, and of the high polish which such surfaces receive. In these places, "I found," he says, "that the bone was more than usually dense, and that there was an almost total absence of Haversian canals, which made the bone more dense; this led me to speculate on the cause of this porcellanous deposit. Recollecting that the French polisher (when he wishes to give a fine polish to rosewood, mahogany, or any other woods which have an open grain) first fills up the pores in the wood with some wax or resinous material, and then polishes, whereby a fine lustre is obtained, etc." To this account I must add that the deposit is quite superficial, reaching hardly $\frac{1}{10}$ of an inch below the surface, and that it never is found save where two bones rub together. Thus, the friction which afterwards produces the polish, causes by its direct irritant action the effusion of the lime-salts. Furthermore, these spots of polished, porcellanous structure are here and there formed of cartilage that has been ossified and partly worn away; here and there of the somewhat hypertrophied bone. Wherever and however formed, the continued friction wears the surface with a rapidity that is not a little remarkable, and the joint-cavities become greatly altered in form, partly by this, but partly and chiefly by another agency, which will be mentioned immediately. Such attrition leaves its very evident marks in lines of polished ridge and furrow, always running in the direction of movement, namely, in straight lines in hinge-joints, as in the patella, femur, and tibia, at the knee; in cycloidal curves in enarthrodial joints, as at the hip and shoulder.

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[1] The hyperplasia is never thus equal and uninterrupted on all sides; but we will leave the matter so for the present, pointing out in future what it is by which the hyperplasia is interrupted and modified.

Thus, to epitomize the above: wherever friction occurs, there we find interstitial hypertrophy with dimensional atrophy, that is, a somewhat solidified bone gradually wearing away; but where no friction and no pressure take place, there we find the direct contrary—interstitial atrophy, with dimensional hypertrophy. In other words, the bone proper (that is, not bone of new formation), in places subject to neither friction nor pressure, becomes porotic, the Haversian canals enlarging to the size of wormholes in old mahogany. At the same time, the marginal hyperplasia above described produces new masses and outgrowths, first of cartilage, and then of bone, the juxtaposed surfaces of which, when they come into contact, form a new portion of articular surface outside and beyond the old and normal joint-area, becoming also, at the points of touching, polished and porcellanous. Such outgrowths greatly deform the joint, and together with the effects of friction above described, may very considerable modify the shape of the part. Thus bony heads, normally globular, become mushroom-shaped, or more rarely conical; hollows which, in their healthy state, are but slight concavities, as, for instance, those on the tibial tuberosities, are transformed into wide and deep depressions; while cavities, naturally deep and cup-shaped, like the acetabulum, may be widened into broad and shallow saucers. Nor is it contradictory of this pathology that the forms produced vary in different cases very considerably, since any peculiarity of posture or of movement, assumed for the avoidance of pain, may greatly modify the situation of pressure and of friction, and therefore the locality of atrophy or hypertrophy.

Let us take, as an example of the effects produced by this singular admixture of hypertrophy and atrophy, such changes as frequently occur at the upper part of the femur. A first sight of the dry bone gives the idea that the neck has wasted and become bent down, so that the head, somewhat enlarged, has become sessile on the shaft between the two trochanters. What really happens is, that all the head, save a little at the lower part, is atrophied and worn away, while by marginal hyperplasia the neck is enlarged, so as to be transformed into something that looks like a misshapen head.

At certain joints, less surrounded than the hip by muscular structures, osteophytic outgrowths are very strongly marked; those which have been already mentioned are frequently craggy, rough, and outwardly uneven, while those from opposed bones that come in contact, receive a porcellanous polish, and at the same time greatly interfere with or entirely prevent mobility. A joint, such as the knee, may thus become entirely motionless, but not by anchylosis, which in this disease is exceedingly rare.

In considering these very remarkable osseous changes, it appears to me impossible to suppose that the malady originates in the synovial membrane, and is then transferred to the bones; perhaps (though it would be contrary to our experience of other joint diseases) it may simultaneously invade all the articular structures.[1] For my part, I believe it to be in its origin osseous, and that the synovial affections sometimes appear before any bony change can be detected, simply because these affections are occult, like other interstitial changes of bone. When we consider that neighboring processes become involved, and even may come to form a part of an abnormally exaggerated cavity—for instance, the coracoid and acromion processes may become a part of the morbid shoulder-joint—we can hardly believe in the synovial origin of such wide alterations situated a long way from that membrane.[1]

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[1] Hueter (Klinik der Gelenkkrankheiten) calls the disease Polypanarthritis.

Symptoms.—Early detection of this disease is very important, since in its later phases it is peculiarly intractable. Although chiefly a disease of old age, it may, nevertheless, attack young persons. More especially should the sort of pains described below be regarded with suspicion when they affect young women whose catamenia are scanty and irregular. The malady may also follow acute rheumatism at a long interval. It may, when uniarticular, be due to traumatism, afterwards spreading to several joints. Exposure to cold, insufficient food, long-continued overwork or mental depression, residence in a damp atmosphere or in an ill-protected building, may be causes of the disease, and may lead to the interpretation of symptoms. But, on the other hand, we find persons well fed and housed, with no possible anxiety, who have never had an illness and never committed an imprudence, who are rosy, cheerful, and digesting and sleeping well, and yet who are crippled by arthritis deformans. When the disease arises from some definite cause, such as a chill, or a distinct attack of rheumatism, the symptoms are clearly marked and rather abrupt, viz., pain and stiffness in one or more joints, with periarticular—and, in the joints, intra-articular—effusion. The case looks like a mild attack of rheumatism. The urine, too, is generally loaded with lithates, but there is no diaphoresis; the skin, indeed, is dry and without acid smell. If there be any pyrexia, it lasts but a day or two. When no distinct causation can be traced—sometimes, even, when this can be done—the commencement is much more obscure; perhaps there is only in one or more joints a slight, hardly noticeable, morning stiffness, which goes off after an hour or two, but slowly becomes more persistent, and affects other parts.[2] I have known this form to be described as "creeping rheumatism." One case, which arose after sudden cessation of suckling, was described to me as "milk rheumatism." During rest, the early phases of the malady are painless; but at a later period, if some of the larger joints are involved, starting pains are troublesome, though never severe. Any movements are more painful after prolonged rest, than when motion has been persevered in for some time. The affected joints may occasionally be the seat of effusion, which in the smaller articulations is slight and transient, but in the larger ones, especially in the knee, is often considerable and persistent. Some alteration in shape is nevertheless perceptible, but less in the joint itself than in the bone immediately adjacent, which becomes irregularly nodose and gnarled.[3] For a long while no further changes in the joints themselves are perceptible, but the progress of the disease may be traced in a remarkable flaccidity of the muscles, very different from their state in other joint-affections. When the malady attacks the hip, the buttock hangs peculiarly loose, and almost pendulous; when the knee, the same may be noticed of the thigh. With this flaccidity, rapid wasting is also combined.

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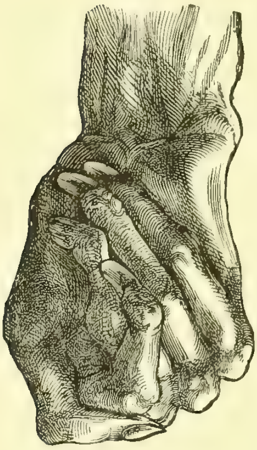
[1] In the above account I have given the result of much independent study of a large number of specimens, availing myself also freely of the works of earlier investigators, namely, R. Adams, "Treatise on Rheumatic Gout;" R. W. Smith, on "Chronic Rheumatic Arthritis;" and Canton, "Surgical and Pathological Observations," a little work from which much information may be gleaned.

[2] A gentleman of my acquaintance, aged 67, began with a little stiffness in the morning about the joints of the fingers, afterwards the ankles, and then the knees; subsequently, almost all the joints were involved, and the painful stiffness became continual.

[3] My experience is, that although the period of synovial effusion is uncertain, it does not begin until the stiffness has lasted some time, often till after nodosities have appeared. In this sequence the knee is sometimes an exception, considerable synovial effusion being much earlier in it than in any other joint.

Fig. 651.



Arthritis deformans of hand.
(After Canton.)

Gradual immobility becomes more and more decided, and at the same time crepitus, distinctly bony and occasionally very rough, can be perceived; in some cases this is so harsh that it can be heard at even a distance from the patient; shortly afterwards, abnormal mobility can very often be detected.

Although space will hardly permit details as to the peculiar deformation of each joint, yet of two it may be desirable to speak more particularly. Of all parts the wrist and hand are the most frequently affected, probably because the most exposed. These extremities are also of use in diagnosis as offering a certain characteristic, and that often when they are by the patient supposed to be exempt. This characteristic is adduction of the fingers. At the metacarpo-phalangeal joint, the index is most affected, and often previously to the others, so that it tends to overlap the middle finger on its dorsal aspect. A little after this the back of the wrist comes to have a hollow look. The radius and ulna, but more especially the latter, which is much enlarged, project. Then follow those enlargements and uneven projections on the knuckles which caused Haygarth at first to speak of "nodosity of the joints." The first phalanx of the thumb becomes strongly flexed on the metacarpus, while the inter-phalangeal joint is straight. After a time are slowly developed very singular distortions and positions of the fingers, which render the hand utterly useless.

The hip may be affected together with other joints; the diagnosis is then simple, being aided and guided by the generally crippled condition; but when that articulation is involved alone, there may be some ambiguity. For instance, it has happened to me more than once that a man having received a blow or suffered a fall on the hip, has declared that previous to the accident he could walk perfectly well; the position of the limb and the crepitus have caused the condition to resemble fracture of the neck of the thigh-bone; but the wasted and flaccid muscles, with certain other symptoms, have negatived such a diagnosis. Afterwards I have elicited from the patient's friends that he has walked lame for years. Therefore, and because histories are not always reliable, it is very important to be able to distinguish accurately the uniarticular disease—the *morbus coxæ senilis.*

The limb is rotated outwards, divergent from its fellow, and shortened—the shortening being in part real, but also in great measure produced by elevation of the corresponding side of the pelvis. The thigh can generally be drawn a little downward, and may also be slightly pushed up again; also, by placing the fingers deeply behind the trochanter, the thumb in front, the neck and head of the bone will be found to have some abnormal mobility backward and forward.[1] These symptoms might all depend on fracture of the neck of the thigh-bone. The disease, however, is distinguished from that injury, by the fact that although in the former voluntary motion is considerably restricted, it is not entirely abolished. The patient can lift the limb a little from the bed; he can rotate it slightly outwards, and also a little inwards; the buttock and thigh are not merely flaccid, but are also wasted. The patient, too, can, if he please, put some weight on the limb, though with pain. When the history is quite reliable, the slow advent of lameness in the disease is entirely different from the onset of the lameness in injury; but when a man with arthritis deformans of the hip has suffered some traumatism, and is also malingering, the above marks will afford the means of diagnosis.

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[1] These symptoms depend upon enlargement of the acetabulum, the usual lesion of arthritis deformans at this place. There are, however, it should be known, a few cases in which the cavity is deepened, and in which the osseous outgrowths from the edge of the socket lock the neck in very firmly; and in such cases the last-named symptom would be absent.

We will take up again the conditions of the disease as it progresses in several joints; patients thus suffering may, nevertheless, continue in very excellent general health, but the joints already affected become gradually more immobile, while other articulations are one after another involved. In some cases, the patient is at last incapable of moving almost every limb; fortunately the temporo-maxillary articulation is rarely involved. But I have seen several patients in whom almost every joint of the body has been so stiffened that they have had to be moved from bed to chair and back again, being entirely unable to assist themselves in the least degree.

TREATMENT.—The treatment of arthritis deformans is by no means satisfactory, more especially when the disease is already pretty firmly established; hence, early recognition is of great importance, although sometimes from its very nature impossible. In other cases, however, the presence of the malady, commencing in a subacute form with joint-pain and a certain pyrexia, together with very acid urine, depositing, perhaps, the red sand, may be suspected, and such cases may be advantageously treated with the alkalies or neutral salts. Aperients, but not purges, should be used, and the diet regulated, but not always in the same direction. When the patient, feeding largely on animal food, takes little or no exercise, we should adopt a treatment directly opposite to that which is required when the disease occurs in the poor and under-fed. But the condition of system is essentially one of debility, and all remedies, both in the subacute and chronic forms, should be prescribed in accordance with that view of its etiology. Tonics therefore, as a very general rule, are to be advocated. Iron is not well borne by the digestive system; but quinine, either as a solid or dissolved by means of citric acid, or, if this be not tolerated, the extract of cinchona, is useful. But arsenic is probably the most valuable of such medicines, and in many cases appears to exercise a retarding effect upon the disease. I believe that I have seen benefit from small doses of the perchloride of mercury, given occasionally for short intervals. Guaiacum, combined with ammonia, appears most useful when the affected parts are cold and clammy. Also valuable are certain mineral waters, especially those that, like the Woodhall Spa, contain iodine or its salts; the waters of Bath, Buxton, Harrogate, Vichy, Aix, and Carlsbad, are likewise useful.

The *local treatment* is to vary according to the condition at the moment. The subacute and painful commencement or interludes, are best treated by rest; if the pain be not severe, mere lying in bed will be sufficient, but if any particular joint be peculiarly painful, a light splint may be applied. If there be inflammatory symptoms, two or three leeches may be employed; but compresses steeped in hot water, or in a solution of bicarbonate of potassium, ten grains to the ounce, with a like quantity of dilute hydrocyanic acid, are better, as being less debilitating. Local applications of belladonna also give relief; blisters, too, may be employed, especially in such cases as are marked by considerable effusion.

When the malady is chronic throughout, as also in the chronic intervals of fluctuating cases, rest is to be avoided. The patient must be directed to take as much exercise as he can without over-fatigue, thus promoting porcellaneous polish of the bones, and preventing the encroachment of osteophytes so near those which spring from the opposite bone as to fix the joint altogether, or beyond the amount absolutely inevitable. It is to be confessed that when the disease has reached this stage, all that art can do is merely palliative; the surgeon must direct his efforts to spare for his patient as much power of movement as possible.

SYPHILITIC AFFECTIONS OF JOINTS.

Syphilitic affections of the joints are very rare, and are among the latest manifestations of the virus. They assume two forms, arising either from gummatous deposit in the perisynovial tissue, or from periostitis of the articular end, which, when it occurs, is usually consecutive to periostitis of the shaft.

SYPHILITIC JOINT-DISEASE FROM PERISYNOVIAL GUMMATA.—This variety, which is the less common of the two, only arises when gummatous products are plentiful in external parts, and in the viscera; the disease is rather an extension from the surrounding fibrous tissues of inflammation, caused by deposit within them of gummatous material, than a primary affection. But it must be confessed that little opportunity for anatomical study of this condition has as yet been afforded. The well-known case of Lancereaux[1] is the only record of pathological investigation of this subject that I can find; it is unfortunate that the period during which the patient was under observation is not mentioned, nor is any account given of the condition of the joints during life. After death, numerous gummata were found in various parts of the body, notably in the liver.

Both the femoro-tibial articulations were enlarged, and each contained more than a glassful of a yellowish, turbid serum. The synovial membranes, thickened and at the same time injected, were studded with several small pseudo-membranous deposits. On the left side, a yellowish false membrane united the two layers of the synovial membrane; on the right side, the synovial bursa of the rectus femoris was not changed. The articular surface of the left external condyle was eroded, and, as it were, ulcerated at one point. The articular cartilages of both patellæ were eroded or ulcerated; there was a velvety condition over half their extent; but these changes were secondary, only the chief lesion affecting the fibrous tissues of the joint. On the right side, a part of the ligamentous tissue attached around the tibia was changed into a uniform, grayish-yellow, elastic mass, about an inch and a half thick at the median line. The mass resembled in many respects the morbid products met with in the liver, being like them formed by a gummy deposit. Except the fibrous band representing the ligamentum patellæ, there were found in it only some fibrous septa, which appeared to divide it into several small tumors. The left joint was similarly affected, except that the cushion of fat behind the patella had not disappeared as completely as on the opposite side. The fatty mass had retained its normal appearance at the upper part; an anatomical examination of the articular gummy masses showed a structure identical with that of the gummy masses in the liver.

By comparing the results of this autopsy with the records of other cases, we may evolve a picture of the disease which is plainly to be understood. The disease is essentially chronic, and is occasionally remittent; it does not appear to affect any joint but the knee; it may be double or single, and is not accompanied by fever.[1] The effusion is clear or opalescent, sometimes fibrinous. When the synovitis has lasted long, or has returned several times, the cartilages, as in all synovitic disease, may be secondarily affected, and the distension may loosen the ligaments. But as the above autopsy and certain clinical observations, to be hereafter mentioned, show, the presence of gummous tumors or thickening is that which essentially gives character to the disease.

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[1] Treatise on Syphilis, Sydenham Society's Translation, vol. i. p. 255.

Symptoms.—The symptoms of syphilitic synovitis, independent of bone-affections, are not, it must be confessed, very conclusive when taken alone, and the diagnosis must rest largely upon the presence of other syphilitic manifestations. At the same time, it must be pointed out that a person with syphilis may also have a joint-disease which is not produced by that affection, although perhaps a little modified by the poison.[2] Nevertheless, there is, as Richet[3] pointed out in 1853, and as the above case by Lancereaux shows, a syphilitic malady of the perisynovial and synovial tissues, having somewhat peculiar symptoms. The patient may or may not have at the period of joint-affection a plainly marked manifestation of syphilitic disease,[4] but when the case is fully investigated, a scar, or, at least, some history of previous syphilitic trouble, can, in all cases, be discovered; for arthropathies are, as already stated, late lesions, more especially those arising from gummata. The knee or knees are distended with fluid, the enlargement being preceded by a sense of fulness and tension; but, at the time of effusion, they are remarkably free from pain, though feeling weak and unsteady; there is very little tendency to that contraction of the flexor muscles, which is so marked a symptom in other acute joint-diseases. This important point is deserving of further elucidation: the ordinary chronic hydrops articuli is not accompanied by any marked pain, muscular contraction, or fever; but that malady is less rapid in its first invasion, and goes on slowly, gradually, and non-intermittingly increasing. The syphilitic perisynovitis, in its most characteristic form, attacks the part suddenly, usually causing considerable pain. The disease frequently disappears, or becomes greatly mitigated, to return with like symptoms again and again; or, if it do not intermit, the pain at all events ceases nearly or entirely; the effusion appears to have no relation to the pain, the patient being able to walk with little trouble, though easily tired. The joint may be subjected to passive movements without pain; but, in some cases, active movement is not quite painless. The limb bears complete extension more easily than flexion. By palpation, a certain thickening of the periarticular fibrous tissues may be perceived; this is not evenly spread over the joint, but appears in the form of somewhat hard, yet doughy, lumps and plates, extending some distance beneath the skin. If the malady have been allowed to continue for a long time, the relaxing effect upon the capsule is the same as in non-syphilitic, chronic hydrarthrus, producing a certain amount of abnormal mobility. In much-neglected cases the cartilages become eroded. The diagnosis, even though in the most characteristic cases all these symptoms be present, can hardly be perfectly certain until the effect of antisyphilitic treatment has been observed.

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[1] Syphilitic affections, however, have been of late shown to be accompanied by an evening rise of temperature. See a report on the temperature of syphilis, Clinical Society's Transactions, vol. iii. p. 170. It is probable that were the cases referred to in the text to be observed at the present day, that condition would be noticed.

[2] It is one of the results of any specialism that its professors are apt to draw many alien things within the confines of their particular sphere. I must confess that some maladies described as syphilitic appear to me very doubtful examples of syphilitic disease.

[3] Mémoires de l'Académie de Médecine, tome xvii. p. 251.

[4] Richet's first patient had at the time no other mark save scars of chancre and bubo; his third had buccal aphthæ and enlarged testicle; the condition of his second was more strongly characterized by condylomata. Of Verneuil's two patients, one was more evidently affected than the other.

SYPHILITIC JOINT-AFFECTIONS WHICH ORIGINATE IN BONE-DISEASE.—These may lead, unless their true nature be quickly discerned, to more serious results than the synovial malady. When syphilis attacks the osseous system, it most commonly affects the hard structure; certainly, when any limb-bone is involved, the shaft is more commonly chosen than the joint-ends. Moreover, syphilis of the spongy portion of a long bone is commonly a later manifestation than nodes, etc., on the tibia or cranium. The lesion takes the form of a gumma, which, on the surface, is circumscribed in a patch or patches beneath the periosteum, and occupies the more superficial layers of the osseous tissue; in the cancellous structure it is more commonly, though by no means constantly, diffuse.

From either of these starting points, the joint may become involved; from the former, the malady spreads by continuity to the synovial tissues, the result being a syphilitic hydrarthrus like that above described, but somewhat more recalcitrant: from the latter arises a malady of far deeper gravity, involving the cartilages, and causing them to ulcerate or to be cast off into the joint. The effused fluid, not large in quantity, is therefore largely mixed with tissue-débris and leucocytes; it is puruloid rather than purulent, for true suppuration of the joint is unusual. This form of the disease tends to terminate in either false or true anchylosis.

The *symptoms* of this malady vary somewhat according to the different modes of attack above described; but both forms have this in common, that they are preceded by the well-known pains in the bones which are so characteristic of syphilis (osteocopic), aggravated at night. If the gummatous deposit be on the surface, the patient will point out the seat of chief pain, and the surgeon will readily feel the soft, nodular enlargement; then, as the disease involves the peri-articular tissues, he will readily detect the localized lumps and patches overlying the joint (described above), and will thence have no difficulty in diagnosis. If, on the other hand, the gummatous lesion be in the interior of a joint-end, the osteocopic pains may not be accompanied by any distinct enlargement outside the bone, nor are the synovial tissues of necessity involved until a later stage of the arthropathy; indeed, it happens occasionally that the cartilages are pretty severely affected before any joint-swelling is observed. Other symptoms, however, should call attention to the locality, namely, difficulty on movement, a sense of weakness in the joint, and, not unfrequently, abnormal mobility. The disease, although chronic and slow in its course, has a sudden commencement, and is excessively painful during the night, but much less so during the day; there is but little tendency to flexion; passive movements, until the cartilages are ulcerated, are not, while active movements are, remarkably painful. When a mild articular osteo-syphilis has been preceded by vague and wandering pseudo-rheumatic pains, not uncommon in syphilis, the diagnosis between this malady and a localized rheumatic affection is difficult; but in the latter disease the joint is red in the beginning, effusion is more manifest, the pains are less uneven throughout day and night, and the urine, more markedly acid, contains a greater quantity of urea; the fever is of a different sort, not the peculiar one of syphilis.

Lastly, osteo-syphilis is accompanied, and frequently preceded, by loss of health, anæmia, skin-discoloration, and other signs of cachexia.

TREATMENT.—The treatment of syphilis by appropriate remedies has already been sufficiently discussed;[1] it need only be said here that such later manifestations as those now in question yield more rapidly to iodide of potassium than to other antisyphilitic remedies, and especially does this remark apply to such maladies as commence in the perisynovial or bursal tissues. Also, it is to be borne in mind that constitutional syphilis confers upon its subjects great tolerance of iodine. Such patients are not only able to take, but even flourish and get fat upon, such quantities as a drachm, or even occasionally on three drachms, of the salt per day. Nor does it appear to me that less than half a drachm in the same period has any effect, either on the disease or on the patient. I cannot speak in quite the same terms of this remedy in the form of disease which brings with it gummatous formations; iodine, though still valuable, exerts less manifest influence in these cases, and, if the patient be debilitated, it should be combined with a tonic, and more especially with arsenic.

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[1] See Vol. II. page 568.

The synovial or perisynovial form of joint-syphilis, thus treated, will get well in from three to six weeks, if at the same time rest by means of splints be enforced; if much intra-articular effusion exist, pressure, and in severe cases puncture also may be added. But as in all manifestations of constitutional syphilis, recurrence is very common. The syphilitic arthritis resulting from bone disease (not from mere periostitis) is far more severe and more lasting. The same plan, with modifications in the constitutional remedies, must be employed. But the case must be watched, lest symptoms of intraosseous abscess should be overlooked. To pierce the bone merely on suspicion that a circumscribed gumma might be found, would be unjustifiable; but it would be equally unjustifiable to leave an abscess, syphilitic or otherwise, to open into the joint-cavity. It is to be remembered, however, that wounds of syphilitic persons heal, as a rule, badly and slowly; hence no paracentesis of the bone should be undertaken unless the signs of abscess are very unmistakable.

Under such medicinal management as above indicated, a large proportion of patients affected with syphilis may stave off or keep in abeyance the recurrent attacks of the malady, while during the intervals their health may be fairly good. As the disease wears itself out or yields to the action of drugs, the intervals become longer and more free from trouble, the attacks shorter and less severe. But occasionally patients are not thus fortunate; there are some who, in spite of antisyphilitic remedies and tonics, constantly get worse, so that, though there are exacerbations and mitigations, there are no longer any distinct intermissions. These patients are generally such as have been in the early stages neglected; more rarely, at the present day, overdosed with mercury; occasionally this obstinacy is due to a combination of syphilis with struma. Very frequently, and in all classes of society, aggravation of the disease is due to irregularity of life, and especially to overindulgence in stimulants, a fault to which the patient is disposed by the depressing influence and accompaniments of the disease. In these cases I have found great benefit to be produced by sending the patient to such baths as Harrogate, which as a sulphur spring is valuable, to the Sohlbad of Kreuznach, or to several waters in the Pyrenees, which, especially if there be a tuberculous complication, have frequently so far altered the conditions of the disease that, though not cured, it has become amenable to treatment.

Joint-disease, connected with hereditary syphilis, is only known in the form of syphilitic dactylitis; even this more usually commences in the shaft than in the joint-end of the phalanx. Nevertheless, it frequently spreads to the joint; indeed, always does so, if two contiguous phalanges be involved. It is typically a gummatous affection, and may even be taken as a type of the process described above. Sometimes it occurs in acquired syphilis.[1]

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[1] See Vol. II. p. 544; Keyes, Treatise on Venereal Diseases, p. 175.

HIP-DISEASE.

The very prevalent affection known as morbus coxæ, or hip-disease, generally attacks children between the ages of two and thirteen years, being most common between the fourth and eighth years. Although children without any traceable cachexia are occasionally affected, the disease has decided preference for those of strumous habit. Doubtless, in a certain proportion of cases, the malady is first set up by some slight traumatism; but in a very large proportion the attack is spontaneous.

The very deep position of the joint produces great difficulties in the thorough investigation of the disease, and these are increased by the oblique position of the femoral neck, which causes the arc of movement to be not in a straight line with the axis of the limb. The former of these two impediments renders the early detection of swelling or of fluctuation extremely difficult, or impossible; hence the particular locality in which the malady commences can only be determined, in any particular case, by contrasting or comparing the symptoms during life with the results of anatomical examinations of other carefully and fully recorded cases. In the following account I shall epitomize the collective results of many such studies, in endeavoring to bring the pathological phenomena into a connected picture of the disease.

Disease of the hip is not in its pathology so peculiar that its inflammatory affections can commence in structures which are never the starting-points of disease in other joints. Nevertheless, a great many writers have believed that this malady arose in the ligamentum teres. The cause of this error depends upon a physiological function of that ligament, and upon the fact that pathological investigation, as carried out by certain investigators, does not go the length of making sections of the bone. The head of the femur, except its lower part, is entirely epiphyseal, and, until after the eighteenth year, derives its nutriment solely from a vessel carried to the digital fossa by the round ligament. When this epiphysis is inflamed, as it very often is, the artery becomes enlarged; hyperæmia, and then inflammatory softening, shortly destroy the ligament itself, which, therefore, is found in the state so often reported—inflamed, swollen, softened, shreddy, or detached. The disease has not, however, begun in that ligament any more than disease of the knee or of the shoulder, when we find the crucial ligaments or the tendon of the biceps altered, can be said to have commenced in either of those structures.

Synovitis does, no doubt, occur at the hip; but I believe not very commonly, and, when it does so, it is, in my experience, a comparatively slight affection due to traumatism or excessive fatigue,[1] and rarely passes on to the stage of disease with exuberant, sluggish granulations, described already as strumous synovitis. The position of the synovial membrane of the hip, so well covered, and therefore so little exposed to changes of temperature or to direct injury, helps to shield it from some of the causes of that disease.

On the other hand, the bones are so circumstanced as to render them very liable to inflammatory attacks, which are very easily transferred to other constituents of the joint, because the Y-shaped cartilage joining the three portions of the innominate bone, and the whole epiphysis whence the head and neck of the femur are formed, are inclosed in the synovial area. At the former place a large part of the pelvic growth occurs; at the latter, an inch and a half or two inches of a large bone is formed.[2] Hence, the nutritive hyperæmia of these parts must be very great, while the supply of blood to the epiphyseal head is simply by one long vessel—that in the round ligament. We accordingly find, at post-mortem examinations, or in moderately early resections, that while the synovial structures are not widely implicated, the bones are generally deeply diseased. The inflammation may attack primarily the acetabulum; a not very common, but a very bad form of hip-disease. It more frequently begins in the femur, either involving all the epiphyseal head, or commencing in, and for a long time confining itself to, the epiphyseal line.

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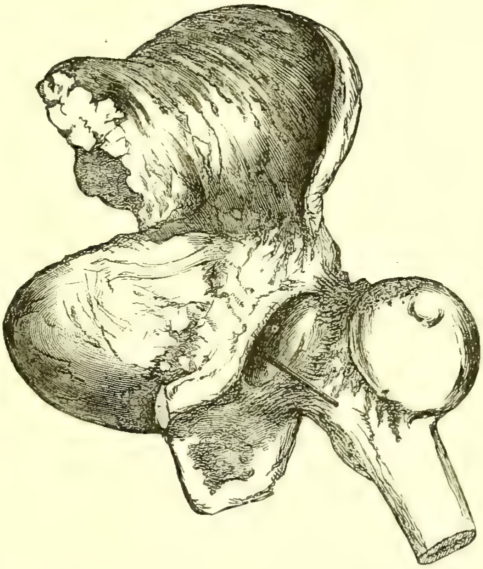
[1] I here except the absorptive diseases described at p. 289 *et seq.*

[2] At birth, the neck of the thigh-bone is represented by a mere groove between the disproportionately large head and the trochanters.

In the first case tumefaction and abscess form, not only within the acetabulum, but also on its inner wall; that is to say, within the pelvis, where they may occupy a large part of the true pelvic cavity, as was the case with the boy from whom the specimen here depicted was taken. The head of the femur is represented as turned back out of the cavity, which is perforated at its fundus, a bristle being passed through the opening and into the abscess, which, as big as an egg, nearly filled the true pelvis. The more usual commencement, however, is in the femur; and it may be well to remind the reader here that the epiphysis does not compose the whole head of the bone, a certain portion at the lower anterior and posterior part being formed by the diaphysis. Epiphysitis is the most common form of hip-disease; it very soon manifests itself with distinct articular symptoms, because the epiphyseal junction is entirely within the synovial membrane. The result, when it runs its full course, is shedding of cartilage from the bone-surface, caries, and atrophy or wasting away of the head.

Fig. 652.



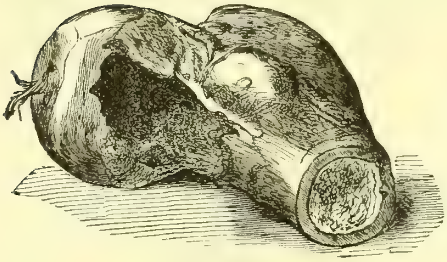
Intra-pelvic abscess from hip-disease. (Acetabular.)

Frequently the inflammation does not attack thus the whole epiphysis; but primarily only the parts immediately adjoining the epiphyseal line, where, indeed, the formative process and consequent hyperæmia are most strongly marked. Thence, as in the annexed wood-cut (Fig. 653), the resulting caries may spread inward and outward on the head and toward the neck. The carious ulceration, having been cleared of granulation-tissue, pus, and débris, is well shown as penetrating to a considerable depth, while the effect of osteitis in rendering soft and breaking up the round ligament (page 380) is in this case exemplified.

But inflammation, beginning thus at the junction, may spread along the whole epiphyseal cartilage, as seen in Fig. 654. If this form of disease run its course, different terminations, according to the acuteness of the attack, will result. If, as is here represented, the inflammation be not very severe, and if it expend itself chiefly on the part adjoining the cartilage of union, the head will be separated, but gradually; it will have time, as in this case, to contract adhesions to the acetabulum, due to the synovial disease which the osteitis has set up. Such cases usually recover with diastasis—a subject which will be again referred to.

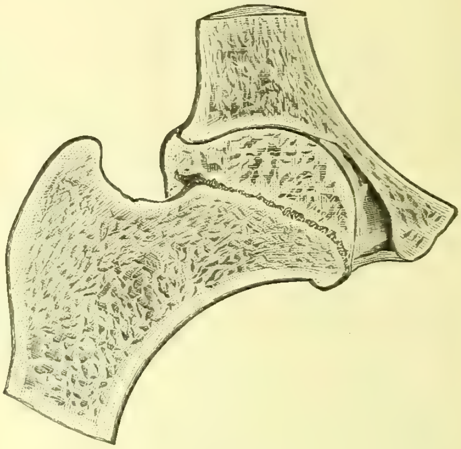
But if the original attack be more severe, causing rapid detachment of the epiphyseal head, and at the same time (as we have seen is the case) destruction of the round ligament, the isolated portion of bone must of necessity perish; it lies loose in the acetabulum, where it acts as a foreign body, and sets up, or at the very least maintains, suppurative inflammation of a very severe character. Such a history is plainly to be read in the preparation here depicted; the epiphyseal head has become detached, and is represented as falling out of the acetabulum, while the margin of that cavity, and the dorsum of the ilium, even as high as the crest, are studded with osteophytes which bear witness to a very violent disease.

Fig. 653.



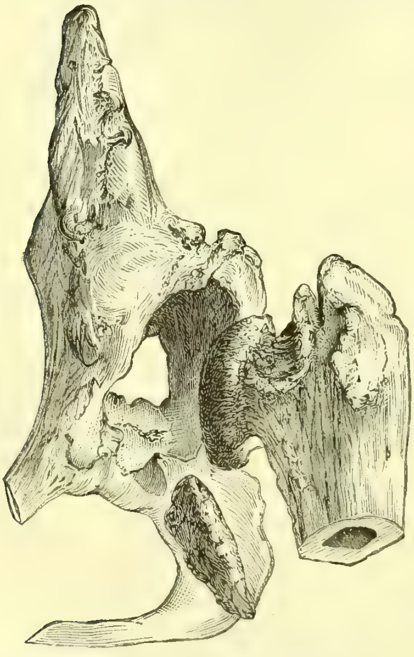
Caries of head and neck of femur from hip-disease.

Fig. 654.



Slow (gradual) diastasis and union of caput femoris with acetabulum.

Fig. 655.



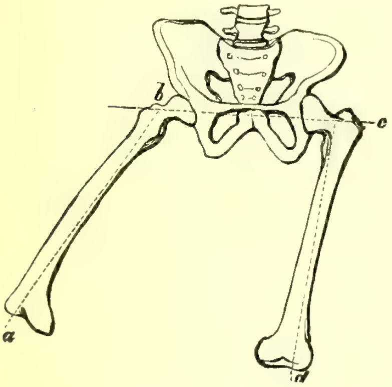
Rapid separation followed by necrosis of caput femoris.

These are the modes in which morbus coxæ commences, so very generally that any other way of beginning is quite a rarity.

We will now go on to study the causes of certain conditions which the changes above described produce. As in other joints, so also here, osseous inflammation, of whichever kind above described, brings with it neuro-muscular phenomena; but the contractions have at this place very peculiar effects on the position of the limb, causing at first the symptom I shall call *fixity*, then *lengthening*, and afterwards *shortening* of the thigh. The first of these is simply due to rigidity of all the muscles passing from pelvis to femur. The flexors, as almost always in joint-disease, are most affected; hence the thigh is, if not quite at first, at least very early, a little bent on the trunk. Then the abductors become most markedly contracted, and the thigh is thrown outward, without, however, losing its flexion. Subsequently the abduction disappears, and adduction takes its place. The cause of this change is quite occult; at present we are without any clue even to an inference as to its nature.[1]

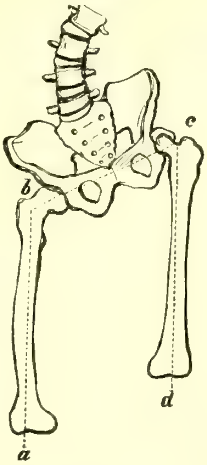
Now it is upon these two positions of abduction and adduction that apparent lengthening and shortening of the limb depend; thus, abduction places the thigh at a certain obtuse angle with a line drawn between the two acetabula—for instance, at the angle *a b c* (Fig. 656); but the individual will not remain in that posture, with the legs straddled wide apart, but will get them more or less parallel, still maintaining the angle of abduction; the only possible way of doing this is to let the pelvis on the affected side droop, as the one knee is brought to lie near the other; the skeleton then assumes the posture seen in Fig. 657; that is to say, the angle *a b c* is maintained, the transverse axis of the pelvis is oblique, one acetabulum lies below the level of the other, and therefore one knee is lower than the other. This is the "lengthening" of hip-disease; it is apparent only, no such thing as real lengthening being possible without either dislocation, diastasis, or fracture. Shortening is easily comprehended by similar observations regarding adduction; the rigid thigh is now placed at an acute angle with a line between the two acetabula, but again parallelism of the two limbs will be sought, and in order to gain this, and at the same time to preserve the angle, the pelvis is lifted; the line *b c* (Fig. 658) again becomes oblique, but in the contrary direction; therefore the pelvis on the side of disease is lifted, and the knee of that side lies higher than the other. This is "apparent shortening;" it is that which occurs when the third stage of the disease is first reached; but a real shortening whose nature will be immediately explained is afterwards superadded. We must particularly note here that the abducted (lengthened) limb would, if measured from the spine of the ilium to the knee or malleolus, seem shorter than the other, because the whole crest is, by that posture, brought nearer to the trochanter, and therefore to the whole femur. On the other hand, because the

Fig. 656.



Abduction by separation of limbs.

Fig. 657.



Apparent lengthening.

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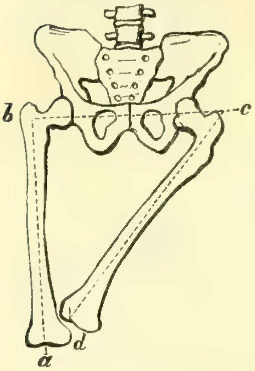
[1] In some cases, abduction appears to coincide with distension of the capsule, adduction with its subsidence; but these are mere occasional coincidences, and not, I believe, causally connected.

Fig. 658.

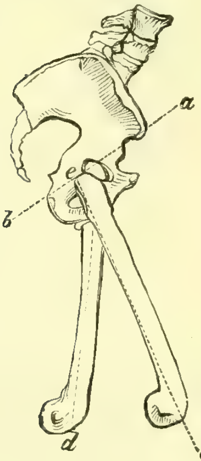


Adduction causing apparent shortening.

iliac crest lies in adduction further from the trochanter, the apparently shortened limb will measure longer that its fellow.

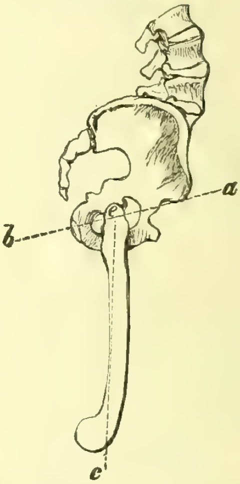
We have still to show how a thigh can be flexed, while, nevertheless, in standing it is vertical, and in recumbency, horizontal. We take as our lines for estimating angles, one drawn from the anterior iliac spine to the tuber ischii, and the axis of the femur. In flexion, the anterior angle between these lines, *a b c*, is more acute than when the leg is extended; now to get the thigh vertical, and yet to maintain that angle, the pelvis follows the movement of the femur as the knee is brought back so as to lie close to the other, and the line *a b* becomes more horizontal; that is to say, Nélaton's line becomes horizontal as the axis of the femur becomes vertical. If the page be turned sideways, so that these figures are in the position of lying supine, and if the words horizontal and vertical be interchanged, the condition during recumbency will also be understood.

Fig. 659.



Flexion of thigh on pelvis.

Fig. 660.



Arching of lumbar spine to permit parallelism of limbs.

It is important to observe that until these positions have lasted long enough to enable the muscles to become contractured, they can be entirely corrected under anæsthesia.

These postures are produced by neuro-muscular phenomena, which have also certain other effects. Although the contraction of the flexors is greater than that of the extensors of the hip,[1] while the abductors and adductors alternate in their predominance, yet the muscles which pass between the pelvis and thigh are, speaking generally, in a state of contraction. The various rotators press the head of the bone inwards, while the longer adductors, the rectus, and probably also the surals, force that part upward. The result thus produced is a mutual excessive pressure between the upper back part of the caput

[1] Probably these latter are not contracted; certainly the chief extensor, the great gluteal, is flaccid.

femoris and the upper back part of the acetabulum; hence follows cartilaginous ulceration at those points—a *decubitus*, or pressure-sore—which is merely secondary, and which constantly occurs, even though the disease may have begun in quite another part of the joint. If this pressure continue, the resultant ulceration becomes deeper and deeper, and involves the bone of both joint constituents; the femoral head is then flattened down while the acetabulum is prolonged and hollowed upward toward the dorsum ilii. Hence arises part of the "real shortening;" the other part results from loss of growth, and, in severe cases, probably, also from decrease in length of the neck, consequent on disease about the diaphyseal aspect of the epiphyseal junction.

The causation of a certain early symptom, pain at the knee, must also be elucidated; it has been ascribed to various causes, but we may eliminate all except two, viz., distribution of nerves, and sympathy of the bone-ends one with the other. Of the former, it may be said that the sciatic and obturator nerves supply twigs to both joints; the anterior crural only occasionally does so. Either of these may, by irritation referred to a distant part, as is so common in nerve-irritation, cause a sensation generated in the hip to be felt at the knee. There is no doubt that the chief factor in this sort of knee-pain is the obturator nerve; it sends a considerable branch to the hip, and supplies that particular part of the knee to which pain, when distinctly localized, is most often referred.

Sympathy between the two ends of the bone has been proved by more than one observation.[1] I myself have in three instances found pressure on a displaced femoral head to produce pain at the knee. Many patients, when the thigh is pressed upward, complain of pain, not at the hip, but at the femoral condyles. It is to be observed, that these sympathetic bone-pains are always centrifugal—that is, they are never nearer to the trunk than the disease, but at a greater distance; the sympathy of the lower end is greater when the upper end than when the shaft is affected.

The course of the disease is, save for these points which arise out of its physiological anatomy, very much as in other joints; but certain other peculiarities may be noted, namely, that suppuration is probably more common at this place than elsewhere, and that dislocation when it occurs is usually complete. Of the former, it must be remarked, that abscess perceptible through the skin is not always intra-articular; that the pus often passes a long way between muscles and along fasciæ previous to pointing—hence, it may make its appearance at the front of the thigh, below Poupart's ligament, or behind the great trochanter; and that the locality is not always a sure guide to the place of formation. For instance, intrapelvic abscess may point at either of the two last-named spots. Pus formed at the lower part of the femoral head may come to the surface in front of the thigh, but more commonly appears behind the great trochanter, following the track of the external obturator muscle.

Luxation of the thigh does not mean that movement from its place which depends on the furrowing upward of the acetabulum, the head remaining in the altered socket; it means an absolute exit of the head out of the cavity, and its lodgment elsewhere. In certain cases dislocation is no doubt sudden, in others it is as certainly gradual. I have in resections found three times the head of the femur resting on the margin of the acetabulum, and marked by a transverse, semicircular, ulcerated depression, evidently the impression of that edge. When luxation is complete, the bone nearly always rests on the dorsum ilii. The only two exceptions that I know of, are a case in which I assisted

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[1] See Wedemeyer, über Caries und Necrose. Gräfe u. Walther, Journal der Chirurgie, 5ter Band, 3ter Heft., S. 626.

Mr. Hancock to resect the hip, and in which the head of the bone was found on the pubis; and another, figured by Mr. Holmes.[1]

A singular coincidence between hip-disease and phimosis was observed by me many years ago. It was so constant, that at last I noted every case of male hip-disease to which I had access. When one hundred had been recorded, I examined the documents, and found that in only six cases was there no phimosis; sixty-six had the affection severely, and twenty-eight slightly. I cannot consider this coincidence a mere chance, but think rather that this condition, so apt to induce frequent and long-continued priapism, has upon the infantile spinal cord a deleterious influence, which is reflected back, sometimes in mere awkward or stumbling gait, sometimes more severely, in hip-disease. Adverse criticism may, of course, find manifold difficulties and objections to this view of the case, but nevertheless the fact remains.

SYMPTOMS.—Occasionally cases of acute hip-disease occur. They are mostly, if not always, examples of osteo-myelitis; and it seems hardly desirable to add to the remarks which may be found in the section on acute osteitis. It may, however, be noted here, that sometimes during an ordinary attack very acute symptoms, but without any great pyrexia, may arise. These appear to belong to another category—namely, to partial luxation, the head of the bone pressing on the edge of the acetabulm.[2] But the vast majority of cases begin and continue throughout chronic, sometimes without, sometimes with a doubtful history of traumatism.[3]

First Stage.—This includes all that part of the disease previous to the advent of those postures which produce apparent lengthening and shortening. The symptoms are very significant; their correct interpretation is exceedingly important. They are: limping, joint-pain and tenderness, sometimes swelling, fixity of the thigh.

Limping is the earliest, or, at least, the first symptom observed; it is at first merely occasional, perhaps only noticeable after unusual fatigue; sometimes most marked at night, sometimes in the morning. Those forms of limping, which evidence great disinclination to place any weight on the limb, indicate a femoral origin. They are all marked by an unevenness of gait, the one step occupying a longer period than the other. After a certain time—occasionally only a few days, more often some weeks—the limp becomes constant, and, at the same time, the child begins to look out of health, worn, pale, and dark under the eyes; he sleeps badly and interruptedly.

Joint-pain is not always the cause of a limp, for, in many children thus affected, examination, unless unjustifiable violence be used, elicits no sign of pain; while other children, apparently not more severely affected, will scream when placed erect, or if the limb be moved. Most children with hip-disease sleep on the back, or on the sound side; a few on the affected side. When the child is old enough to define the place of pain, he indicates one of several spots: occasionally the outside of the ilium; sometimes a spot on the front, inner aspect of the thigh, a little below the apex of Scarpa's triangle; more often the knee; at this last place the pain may be very definitely localized in front of the inner condyle, or may be more vaguely spread over the whole aspect of the joint.[1] In certain cases the pain is very early, previous sometimes to any other symptom save an occasional limp. A means of distinguishing referred pain from any produced by disease at the spot itself, is by making pressure, not with the finger-tips, but with the whole palm, over the sensitive part. This will increase the pain if there be disease at the knee; but if elsewhere, the pain will not be augmented, and may even be relieved.

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[1] Surgical Treatment of Children's Diseases, p. 466.

[2] In one of the three cases above referred to, I resected, for acute symptoms that had rather suddenly supervened, the head of a femur, deeply furrowed by the edge of the acetabulum, on which I found it resting.

[3] Dr. Sayre considers hip-joint disease as usually traumatic (Lectures on Orthopædic Surgery, p. 231 *et seq.*). I can only say that such is not the fact in England, certainly not in London In some cases the parents refer to a fall or injury, in this as in all other joint-diseases, but such histories are generally hunted up for the sake of finding a cause, and often are imaginary.

Fixity of the limb is, of all symptoms hitherto recorded, the most important and reliable. I must strongly deprecate the old rough mode of investigation by forcibly driving the thigh upward against the acetabulum, and would inculcate all caution and gentleness. The fixation of the thigh may simply express itself by a limp, and, even when the patient is quite naked, the surgeon may be unable to ascertain clearly whether or no, in walking, the thigh moves on the pelvis. He will then, placing his patient supine on a sofa, and himself about the level of the patient's calf, take in hand the sound limb a little below the knee, and, while moving it in every direction, observe that the thigh moves freely in its socket, the pelvis remaining quite or very nearly motionless. He then gently grasps the other limb in the same way, and puts it, to a far less extent, through the like movements. If the hip-joint be sound, this limb will move like the other, and he may gradually increase the amount of motion; but, if it be diseased, the thigh will not really move on the pelvis. Watching the salient points of the latter, he will see, by noticing the spine and crest of the ilium, the pubis, and the tuber ischii, that the pelvis follows every motion of the thigh, and that the hip-joint itself does not move at all. The movement is partly at the sacro-iliac joint, partly of the whole pelvis on the lumbar spine. Especially difficult is abduction; all attempts to move the thigh in that direction very evidently impress considerable motion on the pelvis, while the adductor muscles, more conspicuously the adductor longus, are visibly and plainly contracted.

Second Stage, or Stage of Lengthening.—This comes on gradually, when the initial stage above described has lasted some weeks, or, in certain cases, some months. The patient must now be examined both in the erect and in the recumbent posture. In the former the patient stands on the sound limb. The foot of the affected side, only touching the ground by the toes, or very lightly by the whole sole, is in advance; the knee of that side is bent, and also in front of its fellow. The buttock is flattened and flaccid, and its lower fold hangs in a flabby, bagging manner on a level below the other. Therefore the depression behind the great trochanter is broad and shallow, or quite obliterated; and the part looks broader than on the other side. The pelvis is oblique, that is, the iliac crest of the diseased side lies on a level lower than the other, and in consequence the *rima natium* slopes from below upward and toward the side of disease, and the lumbar spine is curved towards that side. If the child be told to stand level, with the feet together and both knees straight, he will, if he bring the feet together, bend the knee; when told to straighten that joint, he will rise on the toes of the sound limb, and, by throwing back the other (diseased) side of the pelvis, protrude that buttock. By these manœuvres, one or all, he endeavors to increase the distance between the acetabulum and the floor; but they generally throw him out of balance, so that he sways about and seizes on any neighboring object. Many children will not make these efforts, but when urged to do so will cling to a support and scream.

The supine position shows that the child curves the body in a very peculiar manner, so that the middle line, which runs from the centre of the pubes over the umbilicus and xiphoid cartilage to the supra-sternal notch, instead of being straight, is very much curved, with its convexity towards the side of lengthening. If the disease be, as far as this stage is concerned, advanced, it will be found impossible to put the body and limbs in a straight line. When having to do with a child or boy, it is convenient to go to the bottom of the couch, take a foot in each hand, and, looking between, move them to the right or left, until the four points above named of the trunk are seen to be, if possible, in a straight line. In older girls the same end may be attained, with less exposure, by passing a cord under some light garment on the lower part of the abdomen, letting one end be held on the centre of the episternal notch, and the other between the malleoli, the pelvis or the feet being shifted from side to side as required. When the body and limbs have thus been placed in as straight a line as possible, the relative level of the malleoli must be compared.[1]

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[1] The pain in front of the thigh may be very severe; I have had two patients who were in the habit of constantly pinching a fold of skin in that place, which they said relieved the pain. An unusual seat of pain is the inner side of the thigh, at the origin of the adductor longus. I have now under my care a young gentleman who has never complained of any other pain.

But in most cases, especially in young children, it is impossible to get the xiphoid cartilage, umbilicus, and pubic junction to lie under this cord, or in a straight line; they persistently remain on one side of it (diseased side). Now, if a finger of each hand be placed on the anterior iliac spines, and a line between them be imagined, or if, from one to the other, a second cord be stretched, it will not intersect the former string at right angles; the two angles which lie below the transverse line will be respectively acute and obtuse, the former being on the lengthened side; and the iliac spine of that side will be seen to lie considerably lower than the other.

I would caution the surgeon to beware of drawing any conclusion from measuring the length of the limbs with a tape, for instance, from the spine of the ilium to the knee or malleolus, and also against comparing the relative position of the knees in sitting. No person with hip-disease, and, therefore, with fixity of the thigh, can bend that limb at right angles to the trunk; therefore none can sit straight and evenly, but must, of necessity, take some twisted posture, which will render any such comparison inaccurate and misleading.

Besides this posture-symptom, the second stage is accompanied by swelling. The post-trochanteric fossa has been described as rendered shallow by flaccidity of the gluteus. It now may be obliterated by tumefaction, which, however, is not very perceptible either to sight or to touch. Nevertheless, deep palpation, and careful comparison between the two sides, may reveal a fluid or semi-solid enlargement behind the neck of the bone. A fluid swelling from synovial distension will likewise show itself in front, a little below the fold of the groin, and opposite to its middle. There exist two sorts of swelling at this place. One is produced by effusion into the synovial membrane; it is characterized by round, soft enlargement, in which fluctuation can occasionally be detected; less often, yet in certain cases, the fluid-wave may be felt between this place and back of the trochanter. But the points most often and most useful to be remarked are, that the inguinal glands, still retaining their normal size, are pushed forward, and feel like small movable beads just beneath the skin. The femoral artery is also pressed towards the surface, so that its beat may be felt with unusual ease, and very superficial below the body of the pubis; at a point, therefore, where its pulsation is in the normal state of parts not very readily distinguished. The other form of inguinal swelling is entirely different. It is mainly produced by enlargement of the glands themselves, which may be felt swollen and big beneath the skin, helping to conceal, or at least to render deeper and more distant, the beat of the artery. The former of these varieties of swelling, if it occur quite early in the case, indicates disease from synovitis; and it may arise at a later period during the progress of a rather acute osteal hip-disease. The latter form is throughout indicative of disease commencing in the upper part of the femur.

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[1] It is well to point out that some persons have one limb (generally the right) longer than the other; but this does not produce fixity of the thigh, nor, in recumbency, obliquity of the pelvis. Coincidence of unilateral growth and of hip-disease might lead to a little embarrassment.

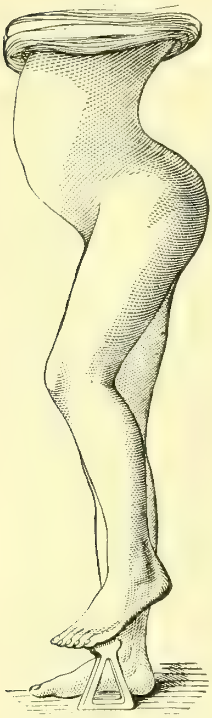
In certain cases, tumefaction also occurs about and below the great trochanter, on the outer side of the thigh. The swelling here is not very distinctly localized; it appears merely as increase of size, as an enlargement, not harder nor softer than the rest of the limb. It is not of good augury, indicating, I believe, extensive disease about the neck, near to the epiphyseal line. I have most frequently observed it in children of feeble constitution; such cases have, with very few exceptions, progressed badly.

Examination into the condition of the iliac fossa should never be neglected. In certain cases swelling in that place is a very early, in others a late symptom. The investigation, if the patient be fat, is not easy; and if he be a frightened child, and cry vociferously, it is, except with anæsthesia, impossible. It may be thus carried out: The patient, lying flat on the back, or a little turned to the sound side, has the knees drawn up and the shoulders supported on a pillow; then the surgeon, standing at the affected side, places his flat hand and fingers a little inside the iliac spines; by a rubbing and kneading movement towards the middle line, he presses the intestines over towards the other side; sinking this hand deeper and deeper in the direction of the sacrum, when he seems to have sufficiently intruded the hand he turns it outward, and may feel all the iliac fossa down to the brim of the pelvis; nor, indeed, should he be content, whenever the symptoms point to pelvic disease, with less than this. This examination should be made in the manner prescribed. If the fingers are merely placed on the flank, and at once pressed outward toward the iliac fossa, the surgeon will probably be baffled, may imagine himself to feel swelling where none exists, or may overlook real tumefaction. What he is to look for is an enlargement of the parts about the brim of the pelvis, obscuring the clearness of its line, and appearing to occupy the lower part of the iliac fossa, and thence to dip down and be prolonged into the true pelvic cavity.

During this stage the thigh wastes more markedly, the muscles, including the large gluteus, becoming soft and flabby. Starting pains increase, often very considerably, and in many cases occupy a larger space than they do at other joints, involving the whole length of the thigh, and passing into the knee; or they may be simultaneous at both hip and knee. When the stage of lengthening has persisted for a certain time, if these pains become more violent, and their recurrence more frequent, we may expect the advent of the third stage, which also, however, may supervene without any such prefatory warning.

Third Stage, or Stage of Shortening.—The change from the position which produces apparent lengthening to that which causes the contrary appearance, has, I believe, never been seen to occur; and yet this change is considerable; the thigh which was a day or two ago abducted, is found on a certain visit to be adducted, and the side of the pelvis which was depressed is now raised. How this is brought about in a limb which has seemed much fixed, and whether it occurs suddenly, or occupies a few hours, is at present unknown. The appearance is absolutely the opposite of that described in speaking of lengthening, but the buttock remains broad, and very often the great trochanter projects very considerably; otherwise, the description given at p. 387, may, by reversing the terms, suffice. When erect, the crista ilii of the diseased side lies higher than the other; the rima natium slopes, and the lumbar spine curves, away from that side. The child stands with the toes on the ground, the buttock protruded on account of the flexion. In recumbency, the crista ilii of the diseased side lies highest, and the xiphoid cartilage, umbilicus, and pubic junction are all on the sound side of a string passing from the episternal notch to between the malleoli.

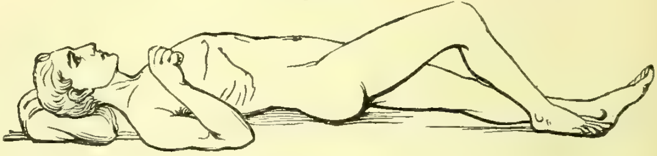
Fig. 661.



Third stage of hip-disease.

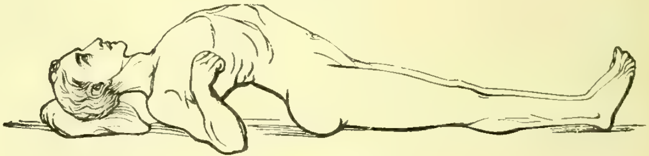
A point concerning the diagnosis of flexion in recumbency must be considered, for it often happens that the patient may be seen lying with the two thighs parallel, well down on the mattress, and apparently quite straight, and yet, nevertheless, there is considerable flexion. This fact may thus be verified. Study the position of the pelvis, and passing the hand beneath the lower part of the loins, observe whether it arches up, leaving a space between itself and the bed. Then take the thigh and bend it up till it stands at an angle of 45°. Again examine the lumbar spine, which will now be found to lie flat. Replace the thigh on the bed, slowly and steadily, while the hand is still kept behind the loins. If there be flexion, as is very general in this stage, the pelvis will be found to become more vertical as the limb descends, and, since the shoulders are still on the pillow, the loins of necessity assume a very considerable incurvation.

Fig. 662.



Flexion of thigh in hip-disease; pelvis in normal position.

Fig. 663.



Flexion in hip-disease. Obliquity of pelvis and arching of lumbar spine when limbs are parallel.

The third stage of hip-disease, is more than any other the period of abscess,[1] although many cases may get well without suppuration. Those who manifest large diffuse swelling on the outer part of the thigh, or in the iliac fossa, do not often escape abscess. In the former case, the pus points generally half way down the thigh, either at the front or at the outer side; in the latter, either in the groin below Poupart's ligament, or at the back of the trochanter, finding its way out of the pelvis by following the track of the obturator internus muscle[2] through the sacro-sciatic foramen. In certain cases the abscesses are merely extra-articular; but more generally the joint is carious, and, the capsule having given way, there is also intra-articular abscess. A probe passed into the outer opening, however, near to the joint, will seldom

[1] Abscess, though it may occur, is unusual in the period of lengthening.

[2] This point of opening must not lead to an error of diagnosis; abscess from one form of sacro-iliac disease opens here, and I have seen the same in one case of spinal caries.

pass into the breach in the capsule, for, as already mentioned, the two apertures rarely correspond, and hence the instrument often does not afford any information.

In a certain number of cases, luxation undoubtedly occurs. I think, even, that some writers insist too strongly on its rarity. When it takes place, it brings with it a considerable abatement of the painful symptoms, which is sometimes complete and permanent, sometimes very transitory. Any sudden cessation of pain should lead to a careful examination. That luxation may occur gradually, has already been pointed out. I have more than once, during resection, found the head of the femur resting on the brim of the acetabulum, and scored by the evident impress of the acetabular margin. Clinically, too, I have learned to regard certain symptoms as indicative of this condition. When a child, suffering the ordinary pain of a chronic but pretty severe hip-disease, is suddenly affected by pain, evidently of a very severe character, holds the limb persistently in his hands, cries violently, and on the approach of any attendant screams with apprehension, or gives signs of severe pain when the bed is shaken; if we learn that since this access of pain first came on, the limb has been more drawn up; if, too, with these symptoms, are combined neither the local signs nor the temperature of suppuration, we are warranted in concluding that some disturbance of relationship between the head of the bone and the socket may have occurred—such disturbance is, in all probability, subluxation, which, if left to itself, will become complete. I was first led to this conclusion, in a case such as I have described, by observing, when, with the aid of anæsthesia, I endeavored to restore the limb to a proper posture, a certain unmistakable snap, such as only occurs on the replacement of dislocated joint-surfaces. Since then, other like cases have occurred to me—in all of them this snap has been felt, in some it has also been heard. Splints having been at once applied, the children awoke comparatively free from pain.

Occasionally it happens that diastasis takes place (page 381), and this also is accompanied by an apparent amelioration, which is persistent or not, according as the epiphyseal head left in the socket has contracted nutritive connections with the acetabulum, or, not having done so, simply remains as a sequestrum (see page 382). Not unfrequently, diagnosis or prognosis requires that a definite idea as to the state of the joint should be formulated. We want, namely, to discover if the abscess be intra-articular, if the bone be luxated, or if the epiphysis be separated. All these points may be investigated at one examination, assisted by anæsthesia.

In diastasis there is very considerable shortening,[1] and the limb is movable; sometimes very movable, and always more so than in hip-joint disease without such complication. Moreover, the shortness may be made to vary without changing the position of the pelvis. By pushing the knee upward toward the trunk, the limb may be reduced to its extreme of shortness; by dragging it down, it may be brought to its normal length, or even elongated. In carrying out these manœuvres, there occurs at a certain level, both in pushing and traction, a jerk or hitch, due, I suppose, to the truncated neck catching around the rim of the acetabulum. All this, to be of value, must take place without movement of the pelvis; indeed, it is better for the surgeon to let an assistant carry out these manœuvres while he himself steadies that part; he will then feel the trochanter gliding up and down upon the haunch.

The diagnosis of real luxation from mere change about the acetabulum and femoral neck, although not difficult, requires some nicety. It has been said that these changes produce a certain real shortening; but this never amounts to so much as to be very plainly demonstrable. Dislocation always causes shortening that can be very plainly seen thus: While the patient is on his back, the surgeon marks with his eye a line at right angles to the mesial axis of the body, running from the sound anterior spine of the ilium across the abdomen; if he wish to be sure, he may even do this with a cord, and make a dot where it touches the pelvis on the opposite (the diseased) side. Now, let him place his fingers on the two anterior spines and note how high the one lies above the level of the other. He then compares the position of the knees or of the malleoli, and if he finds much more difference between these than between the two spines of the ilium, he may infer the great probability of dislocation. Of course, the words, "much more difference," are relative only; but I mean a difference evidently much more than can be accounted for by mere absorption of bone. It must also be remembered that, after luxation, the pelvis, unless the malady have been of long standing, becomes much less oblique. I have, indeed, occasionally seen it resume a perfectly normal position. Another test is Nélaton's line; it also is valuable; but, again, a certain allowance must be made for changes of shape in the bones themselves. The patient is placed on the sound side, and a string is laid athwart the pelvis from the anterior iliac spine to the tuberosity of the ischium; in a sound state of parts, this line always skirts the top of the great trochanter; but when the head and neck of the femur and the acetabulum are altered, that process rises a little, but only a little, above this line; when there is luxation it lies a good deal above it—from half an inch to an inch or more, according to the size of the patient. A dislocated bone always feels blunt and big, occupying a large space on the pelvis. The foot is, at first at least, always inverted.

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[1] The amount of shortening increases with the duration of the diastasis.

The condition of parts in a non-dislocated limb is very different. There is an evident or sufficient correspondence between the amount of shortening observed at the knee or malleoli, and the elevation of the pelvis. The great trochanter does not lie much over Nélaton's line, but it projects considerably, having a rather sharp line above, and occupying but little space on the pelvis.[1]

If the examination is only to be pushed thus far, there is no occasion for an anæsthetic, but if, the femoral head being in the acetablum, we desire to investigate the condition of those parts—whether an abscess be intra-articular, and whether there be caries of the joint-surfaces—ether should be administered. When the patient is fully under its influence, the limb becomes to a certain extent movable, and it should be very gently impelled in all directions, while the hand is placed on the great trochanter. Sometimes certain positions cause an increased flow of pus from the sinuses. This does not always come from the capsule. When caries of the joint exists, crepitus may often be detected, or a peculiar, uneven and jolting method of motion, and frequently the axis of movement is found somewhat abnormal.

Prognosis of Hip-disease.—The prognosis depends in part on the local condition, in part on the state of the general health. If there be joint-caries and abscesses, in and around, discharging large quantities of pus, the tendency to hectic and exhaustion is evident. The advent of lardaceous changes may also be expected. These conditions must be watched for by thermometric observation and the different sorts of examination detailed at p. 365. Increasing suppuration and the amount of these systemic changes may warn us in certain cases that, unless an operation be undertaken, the patient can hardly escape with life.

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[1] The cause of the projection is twofold: (1) The thigh-bone, being higher, rests on a broader part of the pelvis; (2) the trochanter lies above the axis of the head and neck, and must therefore, in adduction, be thrown outward.

But in many cases, after a certain amount of suppuration, perhaps after losing small fragments of bone, the patients begin to get better; the abscesses diminish, the discharge becomes less, the sinuses heal, and the patient gets well, but with a shortened and lame limb. Occasionally, this method of healing leaves behind an abscess which has not fully discharged itself, and the pus of which has become dry by absorption of its liquid part—the residual abscess of Paget; this may again suppurate, perhaps after many years,[1] and may cause the symptoms of active joint-disease to recur.

Treatment of Hip-disease.—At the very first symptom of morbus coxæ, the patient should be placed at complete rest, and, as a very general rule, extension also should be used, either by weights, or by my elastic-extension splint, interrupted by a bracket.[2] At the same time counter-irritants, such as blisters or other revulsives, may be employed. If the symptoms be somewhat severe, or if the constitutional dyscrasia be strongly marked, such antistrumous remedies as have been already mentioned are to be administered. But the patient is not to be left long in bed. When the symptoms of the first stage are slight, a fortnight—if rather more marked, a month—will suffice. Afterwards, one of the splints which permit exercise of other parts of the body, while enforcing complete quietude of the affected joint (described hereafter), should be employed. A large number of cases seen in the early part of the first stage will, if thus treated, get well without suppuration, and with no, or little, deformation or shortening.

But if the surgeon be called in at a later period, during the second or third stage, the good results of his treatment will be proportionately endangered. In the former event, the same management, but longer continued, will suffice, unless there be much distortion. In the latter, it is likely that the posture will require correction, for extreme flexion or adduction will not only thwart treatment, but will add to pain and subsequent distortion. If the malposture of the second or of the third stage be strongly marked, the most prudent course, especially if there be much pain, is to let an anæsthetic be administered, gently bring the limb into a proper position, and at once apply the apparatus for extension. Weight-extension, if used alone, has the defect that, although the limb itself may be motionless, the trunk, together with the pelvis, may be flexed to one side or the other, so that the same peccant angle may be produced at the hip—abduction or adduction being, under such circumstances, caused not by movement of the limb on the trunk, but by motion of the pelvis on the thigh. To obviate this, there should be laid on the sheet which covers the patient three sufficiently heavy sand-bags;[3] one, on the outer side of the affected limb, extends from axilla to foot; one, on the inner side, from the perineum to the same point; while on the unaffected side of the body, another bag is to reach from the axilla to the hip, thus leaving the sound lower limb and both arms at liberty, but preventing improper movement both of the trunk and of the diseased limb. For unquiet, restless children, it is sometimes better to secure the sound limb and that side of the trunk to a long Desault's splint, as in simple fracture of the thigh, without, however, making extension from the foot, which on that limb is unnecessary; but weight-extension must be of course adapted to the other leg. The extending weight should be from one to three pounds, according to the size of the child. It is well, lest the power slowly drag the patient downward, to raise the foot of the bed by placing blocks about four inches high beneath the supports of that end, establishing a general slope downward to the head, and causing the child's body-weight to act as a counter-extending force. But, as a rule, I prefer to achieve both objects—immobilization and extension—by the use of my extension-splint, with a bracket of steel or brass interrupting the supporting parts, and so shaped that the upper or body portion shall be nearer the patient than the limb portion. The former must be long enough to reach from axilla to ilium; the latter from a little below the trochanter to three inches below the foot. The mode of procuring extension has already been described (p. 315). The value of this appliance is, that it secures immobility. It may also be used to rectify malposition, for which purpose it is more effectual than the weight.

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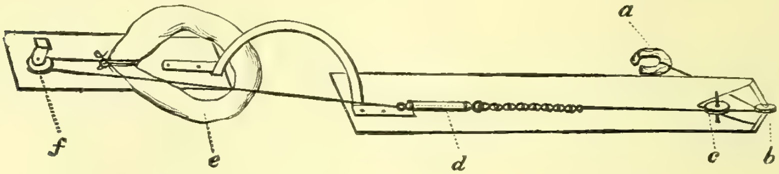
[1] I have several times been consulted in the case of a gentleman in whom such an abscess recurred nineteen years after its apparent cure.

[2] See Fig. 664, p. 394.

[3] The sand must be thoroughly dried and warmed.

Fig. 664.



Bracketed extension-splint for hip-disease.

If, when the surgeon first sees the case, there be less malposture, and if the pain be comparatively slight, sudden rectification will not be necessary; but the patient being placed in bed, elastic extension may be at once applied. It ought to be made in a plane slightly lower than that of the axis of the limb. In some cases the patient may be placed on a bed with a hinged base, so that the part below the middle can be placed at an angle with the rest, the part on which the limbs rest, together with the weight, being lowered a very little day by day. Or the same thing may, with less expense but with more difficulty, be managed with a board beneath the mattress, that can gradually be lowered. With my extension splint it is only necessary to bandage, or, rather, to strap on with a broad belt, the upper division of the splint, and to apply the extension. The elastic force soon tires out the contracted[1] muscles, and the deformity yields more or less rapidly, according to the tension of the India-rubber spring. An attendant must, from time to time, hook this up higher on the chain, to equalize and maintain the force.

By one or other of these means the limb is to be placed in a good posture, and, for a period varying from ten days to six weeks, or even more in very severe cases, the patient is to be kept in bed, and, as far as the hip-joint is concerned, rigidly still.[2] At the end of this period the symptoms, though still persisting, will have become more quiescent, and now means should be adopted which will allow the patient to take exercise, generally with the aid of crutches. American surgeons may rightly claim priority in the invention of splints designed to maintain extension while the patient moves and walks;

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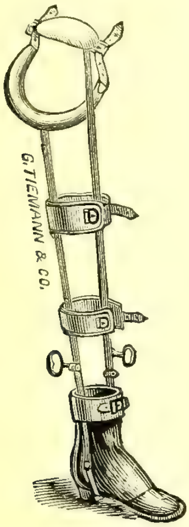
[1] Contracture in the sense already explained has not yet commenced.

[2] I give here what I find, from very considerable experience, to be the best treatment in by far the greater number of cases, though it should be noted that some surgeons apply apparatus, to be now described, and let the patient walk at once. That method succeeds in a certain percentage only of cases.

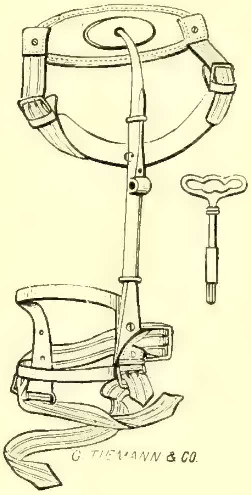
they are constructed with the idea of supporting the weight of the body on the ramus and tuberosity of the ischium, while extension is made, by adhesive plaster or otherwise, upon the limb. Dr. H. G. Davis's splint had certain mechanical defects which have been to a great extent eliminated by Dr. Sayre, who has frequently described his long and short splints. These are used as follows: To the ends of long strips of plaster (in the case of the short splint cut fan-shaped) applied to the thigh, firm webbing is sewn, which, passing under rollers at the lower end of the splint, is secured to buckles at its outside. The perineal strap is fastened firmly, but not too tightly, and then by means of a rack and key the splint is lengthened until it produces a sufficient amount of extension, being slightly longer than the part of the limb on which it fits. The object is to prevent weight falling on the joint, even though the patient stand on his foot, but to allow, and indeed to provide for motion, by placing a ball-and-socket joint at a point opposite the hip. Both these splints have been frequently used by myself as by other surgeons; but they have not found much favor in England, nor generally in Europe. It appears to me impossible to secure their object, namely, extension on the limb while the patient stands on his foot; the failure being due partly to slipping of the adhesive plaster on the skin, partly to the skin itself and the soft parts immediately beneath it moving over the deeper structures and the bone. After a very short time, a large portion of the weight falls, not on the perineal band, but on the hip-joint.

Fig. 665.



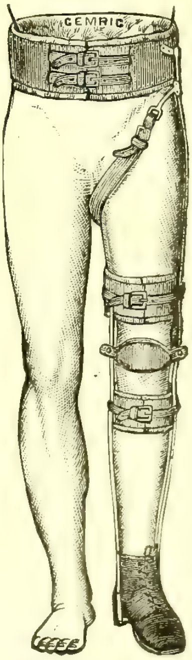
Prof. Sayre's long splint for hip-disease.

Fig. 666.



Prof. Sayre's short splint for hip-disease.

Fig. 667.

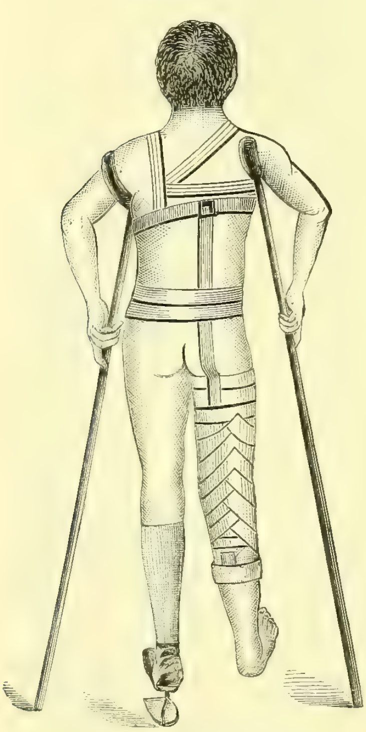


Prof. Pancoast's splint for hip-disease.

Some modifications of Davis's original splint, namely, Pancoast's and Taylor's, do not attempt to make extension by applying plaster to the skin; but the instrument, extending from above the great trochanter, is let into the heel of a well-fitting boot, and, being provided with a slide and ratchet, can be lengthened until sufficient pressure on the perineal strap shows that weight thrown on the foot will, in a great measure, be transmitted to that strap, and not to the joint. Additional security is given by providing the upper part of the appliance with a pelvic and two perineal bands. Dr. Andrews, of Chicago, I believe, first hit on the idea of providing the top of these instruments with a sort of crutch-handle, well padded, and fitting the rami of the ischium and pubis. The upright lies only on the inner side of the limb, and is hitched into the heel of the shoe.

These splints, it is to be observed, all permit of very considerable mobility of the hip-joint; and, indeed, Dr. Jos. C. Hutchison goes further and applies no retentive apparatus whatever to the diseased limb, but, merely supplying the patient with a high-soled shoe for the foot of the sound side, and a pair of crutches, allows him to go about at his own will and pleasure, not even taking the precaution to confine the limb at night. Dr. Hutchison points out, what, indeed, is quite true, that "immobility is secured by reflex contraction of the periarticular muscles, aided by intracapsular effusion, and the voluntary effort to keep the joint at rest on account of the pain which motion produces;" but I would remark, that any extraneous aids for fixing the joint are valuable, according to their power of superseding and preventing those reflex and voluntary contractions which so powerfully press together the articular facets, and thereby certainly add to the pain of joint-disease, as well as aggravate the disease itself.[1]

Fig. 668.



Thomas's splint for hip-disease.

Mr. Thomas, of Liverpool, starting with a different view, desires to secure complete immobility of the hip-joint, by means of a posterior splint with a longer bearing, and entirely devoid of any hinge-joint. The appliance, made of soft iron, consists of an upright, long enough to reach from the level of the angle of the scapula to below the middle of the calf; this must be rather over an inch broad, and thick enough to resist mere muscular force, but not too thick to be bent with wrenches. It must be thus bent or moulded, so as to fit, not very closely, the incurvation of the loins, but much more nearly the nates and its fold; below that last point it may be straight. This portion of the apparatus bears three cross-pieces of weaker and narrower iron, the first of which encircles the thorax, and is provided with a strap and buckle to keep it somewhat loosely applied, while the second encircles the thigh a little above the knee, and the third embraces the leg. These must both be so long that their ends overlap each other in front, to permit which they are placed on the upright with a very slight obliquity. The whole is covered with leather, and bands of webbing passed over the shoulders prevent its slipping down; the splint must be bandaged both to the trunk and to the limb. A high-soled shoe is to be placed on the sound limb, and a pair of crutches provided, when the child is allowed to walk about. This splint has been much employed in England, and in some other parts of Europe. I have had many successful results from its use, but chiefly in early cases, or with very docile patients. It has certain marked defects. Hardly any patients can lie down in it, unless provided with a soft feather bed; defecation is difficult, and generally can only be managed with a flat bed-pan in the recumbent posture. It does not so entirely prevent motion as Mr. Thomas imagines; rotation especially is quite possible within the splint. Many patients, thoughtless or indocile, constantly manage, in spite of considerable watching, to bear a great deal of weight on the diseased limb while partially sitting on the sound buttock, or by kneeling with the well limb on a chair, and letting the foot of the unsound one rest on the floor. High-spirited lads, full of life and fun, are constantly, by some means or other, getting their weight on the diseased limb—not, of course, during the acute and painful stage, but afterwards—and thereby prolonging the disease.

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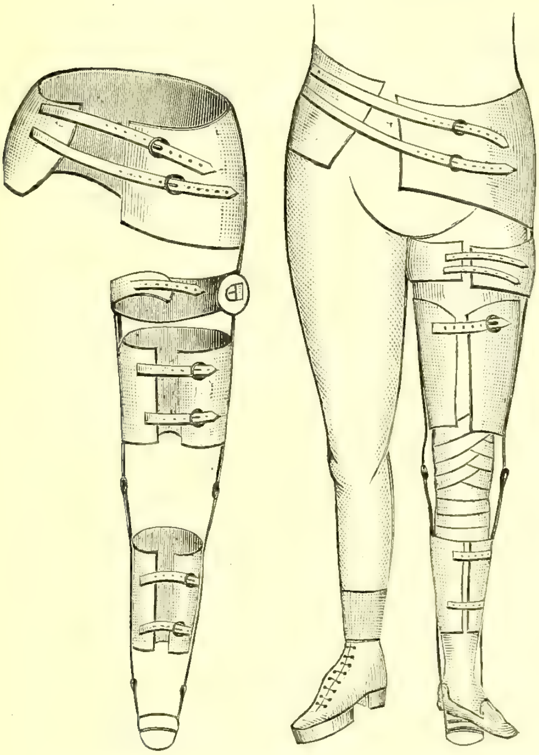
[1] I shall have to show immediately that this method, like the use of Thomas's splint, gives no security, except the will of the patient, against placing weight very frequently on the diseased limb.

Fig. 669.



Dumbrowski's splint as modified for use in hip-disease.

Another splint, of which, from the little experience I have as yet had with it, I think highly, combines the principle of immobility with that of taking the weight off the limb. It is similar to that described at page 317, with the addition of a moulded-felt portion for the ilium, to which the metal rod extends. There is no hinge opposite either hip or ankle; but there is one at the knee. In those that I have had made, my directions have been to place an additional thickness of metal over the splint, from the middle of the ilium to the middle of the thigh, so as the more securely to guard against adduction. With this instrument, immobility of the hip is to a great measure, if not entirely, secured. The foot never comes to the ground, and therefore no body-weight can be transmitted from it to the hip; care, however, must be used that during its application the limb is drawn well down, or weight is likely to be transmitted upward from the splints around the thigh and leg. A great advantage is, that mobility of the knee is not interfered with. After a very little practice the patient can walk quite well with this splint, without crutches.

When the foregoing few pages are considered, it will be impossible to deny that the surgeon has a very wide choice of appliances for the treatment of hip-disease; and, indeed, if we could accept, without any grains of salt, the dicta of each inventor, any and all cases of hip-disease would be easily curable. But a saying of my revered teacher, Mr. J. H. Green, was marked by his well-known wisdom. "Whenever many instruments are invented to fulfil a given purpose, we may be certain that not one of them is capable, under all circumstances, of satisfactorily doing so." And thus, although by these various means—even by Dr. Hutchison's absence of appliance—success will, in a certain number of instances, follow; yet in certain cases, in spite of the most careful and skilful treatment, caries and suppuration will set in and continue. Such cases occur in persons in whom the strumous, scrofulous, or tuberculous taint is strongly developed, and in whom inflammation of bone (the part primarily attacked) runs on to exuberant granulation, perhaps with caseous or fatty degeneration, followed by softening and suppuration. That the various extension splints of Davis, Sayre, Taylor, Andrews, and others, have been more successful in America than in Europe, is, because in the younger country struma is less widely spread, and less deeply scored, and patients have greater facilities for obtaining fresh, good air than on this side of the Atlantic. Nevertheless, I must repeat that the right idea, and that most likely to produce good results, is the American, viz., to get the patient moving about as soon as possible. In the earliest stages of the more chronic form of the disease, it is evident that Dr. Hutchison's plan may in some cases suffice. Sayre's or Taylor's splints are admirable in cases which are rather more acute; but in the severer forms even these do not answer, for excision is an operation which is still practised in America. In such cases we must not only secure the joint against pressure, but also, by some means other than muscular contraction, against motion. Thomas's and Dumbrowski's splints seem to me the best which have been devised up to the present time; the latter is that which I choose in severe cases. The defects of both have been mentioned; those of the latter are apparently inseparable from any immobilizing appliance.

When suppuration supervenes, the surgeon must be guided in his treatment by its quietude or vehemence. If the formation of pus be accompanied neither by pyrexia nor by marked increase of pain, the same treatment, that is, rest to the joint and movement in other parts of the body, should be maintained; and the surgeon should wait until the abscess is pretty near the surface before interfering; when near enough, he should open it pretty freely, wash or syringe out the wound, and pass just within its lips a drainage tube, still persevering in the same treatment, and being very careful to maintain the limb in a straight line with the body, and as little adducted as possible. Many children go through a lengthened period of quiet suppuration, and ultimately get well, with a limb, it must be confessed, a good deal shortened—partly by position, partly by alterations, already described, about the cervix and acetabulum, partly by cessation of growth. The joint too is generally stiff.

But if suppuration be more acute, and be attended by pyrexia, and by very considerable increase of pain, it will be necessary, for some time at least, to enforce recumbency, and to keep up extension with immobility, by means of one of the appliances already described; it may be desirable to carefully examine and correct the malposture under an anæsthetic,[1] and, if so, this must be done with the greatest gentleness. At the same time, abscesses should be sought for, and, if of sufficient size and tenseness to be a probable source of pain, should be opened with proper antiseptic (not necessarily Listerian) precautions, and then syringed and drained. In a few days or weeks, when fever has subsided, the patient may again be provided with a suitable splint, and allowed to go about.

Intrapelvic abscess, especially if large, is a very serious condition in hip-disease, generally indicating necrosis, present or soon to follow, of the acetabular floor. Such disease, however we may treat it, by rest, tonics, and exercise, usually demands excision, and an opening, either by removal of sequestra or by trephining, through the acetabulum. Sometimes the abscess discharges itself either below Poupart's ligament or through the ischiatic notch, and débris of bone may come away, and, after years of suppuration, the patient may recover. But, also, I have known such an abscess to open into the rectum or bladder. Every case of large intrapelvic abscess is attended with danger, either from bursting into one of the cavities above named, or from continuing for a lengthened period, profuse suppuration ultimately wearing out the patient.

Suppuration in the hip-joint is a disease during which the surgeon must in great measure wait upon events, taking care to maintain the limb in good position, to keep the discharges free from putrefaction, to uphold the patient's health and strength, and, if necessary, to seize the proper moment for excision, which, however, if patience and care be exercised, is not often needed.[2]

DISEASE OF THE SACRO-ILIAC JOINT.

The synchondrosis between the sacrum and ilium differs from the joints with which we have hitherto had to do, inasmuch as there is here no true diarthrosis, but a half-joint—an amphi-arthrosis. The two bones are chiefly bound together by coarse-fibred ligament, but at the auricular part a layer of cartilage covers each bone. This is considerably thicker on the sacrum than on the ilium. Between the two, lies, in some persons, a yellow tissue, very like the central parts of the intervertebral substance. In other subjects a bursa occupies that situation.[3] Hence, as the constitution of the joint is simpler than that of others, so also are its diseases. They are all due to osseous inflammation and its effects—caries, caries necrotica, and, when occasionally a larger sequestrum entitles the disease to be so named, necrosis. The locality, however, where these processes originate causes a very considerable difference, from what they present elsewhere, in their symptoms, prognosis, and treatment; and therefore cases of sacro-iliac disease, though simple in pathology, are, clinically, often extremely obscure.

In many cases the inflammation and its resultant caries commence at the front of the sacrum, being exactly similar to spinal caries; only, as the conjoined parts of that compound bone are not movable on each other, no angular curvature takes place. The disease may spread upward and downward, as well as backward towards the sacral canal, and may commit great ravages before invading the sacro-iliac joint; or it may extend laterally, and very rapidly involve the synchondrosis. Another form of the disease attacks *ab initio* the lateral surface of the sacrum, or more rarely the auricular face of the ilium.

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[1] The possibility of subluxation (see p. 391) must not be overlooked.

[2] The question of hip-excision, early or late, is treated of in another part of this volume.

[3] For anatomical details, the reader is referred to an excellent monograph by Luschka: Die Halbgelenke des menschlichen Körpers.

After a certain time suppuration is set up, and the resultant fluid finds its way to the surface in one of four directions. It may, if the disease be low down on the sacrum, appear about the anus, simulating an ordinary ischio-rectal abscess. If higher on the front of that bone, it passes along the pyriformis muscle, and points behind the great trochanter. If at the posterior part of the synchondrosis, it shows itself over the sacrum. While in some cases it appears under Poupart's ligament, I am unable to specify the exact place of caries which produces pointing in that locality. Not unfrequently the pus has not sufficient exit at the spot first selected, and then points also in one of the other places. The abscess being opened, a probe may be passed along its cavity, and may, in certain cases, impinge upon dead or diseased bone. This happens more frequently when the opening is either behind the sacrum or at the groin. It is generally impossible to touch the site of disease when the pus has pointed either behind the trochanter or near the anus; but I have twice succeeded in doing so from the former place, once from the latter.

The prognosis of all these cases depends on the locality of the disease, and on the mode of termination taken by the inflammation. The malady which is above described as spinal caries affecting the sacrum, terminates, as a rule, sooner or later in death, which is generally lingering, and ultimately due either to exhaustion, to lardaceous disease of the viscera, or to pulmonary complications. The disease affecting primarily the lateral surface of the sacrum, or the ilium, is of worse prognosis the further forward the disease is situated. In quite young people the inflammation may end in necrosis, which is more hopeful than caries.

SYMPTOMS.—The first signs of sacro-iliac disease differ considerably, according to the particular part involved. In some cases the earliest symptom is pain along the sciatic nerve; and this, when the disease affects the front of the sacrum, and before it encroaches on the joint, may be for a long time the only complaint; nor, indeed, at this stage, is any clear diagnosis possible. Suspicion as to the condition may be aroused by pressing from the front of the abdomen backward. This in sciatica does not, but in sacral disease occasionally does, cause pain. Succussion and percussion at the back of the sacrum are frequently painful in commencing caries. Examination by the rectum affords, unless the disease be too high, useful information, pressure backwards causing considerable pain. If the disease do not spread laterally, but simply erode deeply towards the sacral canal, the symptoms are very obscure, and the diagnosis exceedingly difficult.

When the lateral surface of either ilium or sacrum is affected, a peculiar instability, lameness, and weakness of the lower limb is produced; the pelvis, too, becomes oblique, and the leg of that side is apparently lengthened, rarely shortened.[1] In this state there is some resemblance to hip-disease; but the diagnosis is not difficult, because *there is no fixity of the thigh.* It is true that movements may be painful, but if an assistant fix the pelvis without too much pressure, the pain ceases, or is mitigated. If the patient be directed to raise himself on the toes, and then suddenly to come down with a sharp jog on the heels, considerable pain will be felt. Also—and this is a very important symptom—if the surgeon places a hand on each ilium of the recumbent patient, and then by a sudden movement of both towards the middle line compresses the two bones as though he would drive them together, and if, when an assistant steadies one side by firmly grasping the ilium and its anterior spine, the surgeon, holding the other bone in a like manner, jerks it outward as though he would sunder the two ilia, pain nearly always follows one or the other, sometimes both movements.

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[1] I saw in one case, in a lad of 14, a shortened limb with a large abscess behind the trochanter. The shortening amounted to nearly 1½ inches, and on this account the possibility of the disease being sacro-iliac was doubted. The boy was very ill when he came into the hospital, and died in about three weeks. On post-mortem examination, extensive disease on the front part of the sacrum was found, involving deeply the right synchondrosis.

When the disease attacks the posterior part of the juxtaposed surfaces, there are pain and swelling, and subsequently abscess inside the posterior iliac spines.

With attention to these details, the diagnosis of the disease, when either primarily or secondarily it invades the joint, is always feasible. But to detect a deep caries of the sacrum, especially if it lie beyond the reach of a finger passed into the rectum, is occasionally impossible. In 1879, a man aged 24 was under my care with obscure symptoms and great weakness; he was evidently very ill. After seven weeks, an abscess appeared under Poupart's ligament, and twelve days afterwards he complained of weakness in the right leg, which he could not lift from the bed; the attempt to do so gave him great pain; the limb was lengthened, but the hip-joint was perfectly free. I now diagnosed disease of the sacrum, spreading towards the right ilium. Exactly a week after this he had four fits of convulsions, became comatose, and died. At the post-mortem examination, a deep, carious ulcer was found in the first and second portions of the sacrum, and involving also the lowest part of the last lumbar vertebra. The spinal canal was perforated, evidently recently, and was full of pus.

Treatment.—The treatment of sacro-iliac disease depends upon its locality, as above described. In cases of extensive caries of the front of the sacrum, we can do but little further than trust to rest and tonics. But when the lateral surface only of the sacrum or ilium is involved, we may be more hopeful of doing good by treatment. Rest should be enforced, at first on the back, and, if the disease be not severe, a pillow under both thighs and knees is advantageous, as patients move much less in such a position than when allowed to lie straight. If the symptoms be rather acute, I have found advantage in placing a Desault's splint on the limb of the sound side and making weight-extension on the other. If the patient be restless, these appliances may be supplemented by laying over the patient a sheet weighted with sufficiently long sand bags. If there be much pain, great relief is obtained, and I think the disease may sometimes be checked, by drawing a line with the actual cautery along the joint, or by making by the same means an eschar just inside the posterior-superior iliac spine. Of course, when the patient lies on his back, this cannot be done; a prone couch must first be procured. Even then, however, such treatment has its disadvantages, since the cicatrix, if the disease be protracted, may give way when it becomes necessary that the patient should resume a supine position. For the same reason, blisters can only be used if a prone couch be available.

If an abscess form over or close to the sacrum, it should be opened sufficiently early, and the surgeon should take this opportunity of examining the condition with his finger and with a probe. In some cases a very superficial, in others a deeper caries will be found; in some an opening, a sort of osseous sinus or cloaca, will be found passing through the joint to the pelvis, or again in others the probe impinges on a sequestrum. In all these events, surgery will be of benefit. The removal of a sequestrum by enlarging the opening has, twice in my hands, proved curative; and when caries, lying at the back of the joint, is accessible without any great difficulty, a gouge and the osteotrite will remove the disease, and may entirely cure it, though probably slowly.

But when a passage leads right through the sacro-iliac joint into the pelvis, very careful examination and consideration of the case are required. The passage may either affect the joint only, or it may be a sinus leading to very extensive disease in front of the sacrum. All this must be examined into by the methods above described. If no clear evidence of anterior sacral disease can be found, the proper course is to enlarge this passage, clear away any softened bone with a small trephine or with a gouge, and pass a drainage-tube into the pelvis. Such treatment will often be useful,[1] but the case will progress very slowly.

If the surgeon have reason to believe that the front of the sacrum is diseased, his course will depend upon the more or less debilitated state of the patient. If he be emaciated, and much worn by pain or by suppuration, there is probably nothing to be done save by rest and medicine to alleviate his sufferings. But if he be still fairly strong and robust, I would strongly advise perforation along the sinus-track, and drainage. The rapidity of the disease is certainly lessened by keeping the pelvis and the carious surface as free from pus as possible.

ANCHYLOSIS.

The term *Anchylosis*, or *Ankylosis*, which is derived from a Greek word (ἀγκυλόω, to bend sharply), did not originally signify, as it now does, fixity or stiffness, but a bend or angle. This singular change in meaning necessitates the use of awkward and pleonastic language; we often have to speak of a straight or of an angular anchylosis.

Anchylosis has been frequently mentioned in the foregoing pages as one of the modes in which affections of joints may terminate; it is therefore not a disease, but the more or less inconvenient result of a past malady. It is due to the adherence together, by bands of new and abnormal material, of two joint-bones. The new material is formed from inflammatory products, nearly always from granulations which have become tissue that may have remained fibrous, or may have developed into bone. In the former case, the anchylosis is called false, in the latter, true anchylosis.[2] The new material is an inflammatory product, whose origin has to a certain degree been traced. We will here take up the narrative at that point when either a synovial or osteal inflammation has destroyed the cartilages and the articular lamella, filling the joint-cavity with granulations springing from the synovial membrane and from the bony cancelli, or rather from the membrane lining the cancelli. When these granulations, more especially those from the two opposite bones, have coalesced, the next step is the conversion of these embryonic formations into fibre-cells, and then into a coarse, cicatricial fibrous tissue, which, of course, involves also the granulating synovial and perisynovial structures. Thus, the two bones become joined together by a strong bond which has taken the place of the joint-cavity. If a section be made of an articulation advancing towards this condition, it will be noticeable that fibrification of granulations proceeds chiefly from the bone; from every cancellar wall a fasciculus of fibres appears to spring, and to advance into the midst of the granulations, the separate bundles diverging a little. In the interspaces formed by this divergence, may still be seen collections of granulation-cells—round in certain parts; spindle-shaped, or already becoming distinct fibre-cells, in others. Wherever the tissue is more advanced, no such structures remain; the whole mass has become fibrous. In the mean time, the granulating synovial tissues likewise cicatrize in the same way; yet it does not appear that fibrillization spreads thence much towards the central parts of the new tissue, but rather outwards, into as much of the periarticular tissue as was previously inflamed. Now, in all cases, as in every cicatrix, this new tissue has a great tendency to contract; hence, unless prevented, the bones will become, for a certain time after fibrification is completed, more tightly bound together, and the circumference of the part, no longer deserving the name of a joint, will diminish. Any sinus-mouths that remain will from the same cause be drawn inward, and become depressed cicatrices. But a further step in organization is often taken; the fibres become bony, ossification creeping along them from the cancellar plates towards the centre, forming, since the fibres are interlaced, a bony network, which afterwards is fashioned into properly-formed cancelli, while the outer layer becomes a cortex of solid osseous tissue; so that ultimately a section through both bones will not exhibit any line of junction. Before me now are two such sections, one of the hip and one of the elbow; in neither is it possible to trace where the one bone begins and the other leaves off, neither can any intermediate uniting material be found. The process, as thus described, is a slow one, such as may follow chronic disease; and, indeed, when anchylosis results from acute malady, the production of its false form is generally, of the true form is always, slow. But there are certain diseases, as for instance dry synovitis and some forms of absorption-disease, which seem to result in a very rapid, true anchylosis. The process whereby such a result can be so quickly achieved is very difficult to understand; it is probably, however, much the same as, only much more rapid than, that above described. We know that there is such a thing as an acute ulcer of cartilage, with clean-cut edges; there is therefore no difficulty in that direction, but the rapidity of bone-formation is not easily comprehensible.[1]

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[1] Three years ago I performed this operation for a young woman, and in three months she was able to walk short distances without pain, wearing a broad belt. The discharge from the wound became quite trifling, but this remained open for nineteen and a half months, and then healed; she is now perfectly sound.

[2] Other causes of joint stiffness, viz., thickening and shortening of synovial and perisynovial tissues, and muscular contraction, will be discussed hereafter.

Every stiffened joint, however, does not owe its immobility to anchylosis; for, as we have seen, synovial disease may expend its chief activity on the surroundings of the joint; or, again, a synovitis may have been cured at a stage when only a part, at the periphery of the articular cartilages, has been destroyed, the cavity having been encroached upon but not filled up by inflammatory products. In the former case, the loss of mobility is due to periarticular impediments; in the latter, to what are often termed bands of adhesion. These bands run from bone to bone, attached to points whence the cartilages have disappeared, and projecting from the thickened synovial membrane into the cavity, as the columnæ carneæ of the heart project from the wall into the lumen of the ventricle. Their ill effect on the function of the joint depends upon their brevity and upon their position. As a matter of fact, these two causes of joint stiffness are usually combined; bands of adhesion probably never occur without periarticular impediments, though the latter may occur alone.

To complete this view of joint-stiffness, we must add yet another cause, namely, muscular contracture, the pathology of which has already been examined. With this is frequently combined fascial shortening, sometimes merely the result of long-continued position, but sometimes also due to inflammatory changes propagated from the perisynovial structures.

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[1] Patients with the diseases in question suffer great pain, or are very ill; so that the affected joint is likely to escape examination, and there may in these cases be some error of observation.

The *diagnosis* between true anchylosis and all other forms of joint-stiffness depends upon a perception of entire immobility, which is much more easily made out when the surgeon has to do with a joint that lies between two bones of considerable length, such, for instance, as the knee, than when one of the bones is short, well covered, and difficult to fix, or has other joints in close proximity to that which is being examined, the problem then being difficult, and sometimes impossible of solution. Some aid may be obtained by watching the muscles which move the joint; in true anchylosis these remain during examination perfectly passive, but in the false form of union the flexors twitch on any attempt to straighten the extensors, or any effort to bend the limb. The twitch, if the bonds of a fibrous anchylosis be very short, is often slight enough to be doubtful. In true anchylosis, the muscles above the joint are more completely wasted than those below. If points of bone close to the joint, both above and below, be sufficiently superficial, the surgeon may listen through a stethoscope placed on the one, while the other is sharply struck, an ivory pleximeter being interposed. The sound transmitted from one bone to the other will be much clearer and brighter if the anchylosis be true, than if it be false.

When some mobility, muscular twitching, or other symptom, indicates that no true anchylosis exists, there still remains to be discovered the cause of what immobility there may be. A false anchylosis, if the bones be very closely bound together, yields but very little, and even that little with a reluctance which it requires some force to overcome; but when the uniting fibres are longer, and the bones therefore further apart, the joint may permit movement through a certain space. The movement, however, is not entirely free, still requiring some force, and the more according as the limb is brought further from its accustomed position, until at length it will go no further. The movement is constrained, and the check gradual.

When the so-called bands of adhesion produce stiffness, lameness of various kinds and degrees may be produced. All movements, for instance, may be free save in one direction; or they may be all free to a certain, perhaps to a very small, degree, but within that degree perfectly free—restricted but not restrained. The check is very sudden, and, as a rule, unyielding. The same thing may be produced by ligamentous shortening, but when the limb is moved as far as it will go in the restricted direction, and a little further propulsion is added, bands of adhesion, being stretched, give a more or less sharp, sometimes a sickening pain; while shortened ligaments are always painless, or nearly so, when moderately stretched. Muscular contracture rarely stands alone as a cause of joint-stiffness, but when it so far predominates as to be considered in the question of diagnosis, there will rarely be any difficulty in distinguishing it from other conditions, even during consciousness. The limb moves quite freely till checked, and is stopped by an elastic and yielding hindrance; pushed still a little further, and suddenly released, it flies back as though by a spring. During these manœuvres the movements of muscles and tendons can be very plainly felt.

But, unless the case be almost self-evident, it is better to put the patient under the influence of ether, after he has been examined during consciousness. This rule especially applies to such joints as present difficulties in the matter of diagnosis, and particularly to the shoulder, hip, and ankle. The advantage gained by a resort to anæsthesia is absence of muscular resistance, permitting the recognition of slight flexibility or rotation, which could not otherwise be detected.

Treatment of Anchylosis.—In order to advise whether joint-stiffness should be subjected to any treatment, many points have to be considered: (1) The inconvenience which the immobility produces. (2) The amount of advantage which any interference is likely to confer. (3) The severity of any operation necessary to produce adequate results.

The decision of the first question must depend in part upon the importance, in part upon the position of the joint; for instance, stiffness of the hip is a matter of more importance than that of the knee, and more important than that of the ankle, while stiffness is of less importance at the shoulder than at the elbow, because mobility of the scapula so greatly compensates for fixity at the scapulo-humeral joint; but the locality of the stiff joint is of less moment than the posture in which it has been anchylosed.[1] Thus, a shoulder fixed very close to the side, a straight elbow, a flexed wrist, a flexed hip or knee, are all very inconvenient; while the ankle fixed in any posture but such as allows the foot to lie at right angles to the leg is, according to the amount of its deviation, very awkward; therefore, to overcome joint-stiffness in any of these inconvenient postures, an operation may be advised of much greater severity than would be desirable for any of the joints in a less inconvenient position. Especially, too, must we take into consideration the worldly position and surroundings of the patient, whose usual occupations, whether for pleasure or livelihood, may be entirely prevented by fixity of a joint in some awkward and embarrassing posture.

The problems with which the surgeon has to deal are these. In case of fixity in an inconvenient posture, can a better position be secured? And whatever be the posture of fixity, can we give to the joint motion through certain limits without at the same time producing abnormal mobility? The answers to these queries depend, in part, on the joint affected, in part on the cause of stiffness. The relative ease with which these causes are overcome lie in this order: Most easy, other things being equal, is muscular shortening;[2] next, perisynovial thickening and bands of adhesion; third, false anchylosis with long fibrous bonds; fourth, false anchylosis with short bonds; fifth, true anchylosis; and in the same order stands the possibility or probability of securing some mobility. Those joints in which the socket of the one bone does not much embrace or surround the head or condyle of the other, are more readily changed in position than others, and mobility is more easily conferred upon them; but such joints, the area of contact being small in proportion to the size of the articulating surface, are apt to be thrown by ill-directed force into subluxation, or to receive mobility in abnormal directions.

We will, for the present, leave the methods of dealing with true anchylosis, and study the treatment in different articulations of other forms of joint-stiffness; we shall then be in a better position to consider the sort of cases which may be subjected to those methods, and the cases which should be let alone.

The general method of treatment, and the precautions to be observed, may be given thus: In mere contracture, section of tendons, muscles, or fasciæ, will be sufficient to allow replacement and mobility; but since some of the other causes of fixity are usually also present, it will be better to be always prepared for further interference. The patient should be completely under the influence of ether. If scars are situated on the side towards which the deformity inclines, they will have to be separated with a tenotome from underlying parts; if they are flat, and have a pretty even surface, this can be done at the time when the other steps are taken. If they are depressed and funnel-shaped, they can rarely be divided without cutting off their neck, and leaving a gap in the midst; if this is on the side of deflection, the hole may, in stretching, tear. Hence it is better to divide such depressed cicatrices some days before the chief operation, and, by moving them frequently over subjacent parts, prevent them from again becoming so closely attached. This little procedure is generally so painless that it may be done without using an anæsthetic.

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[1] In the preceding pages I have very frequently insisted on treating joint-diseases in a good position, but the subject may here again be reverted to as being so extremely important, since the best posture for treating articular inflammation is also the most suitable should anchylosis occur.

[2] Save in certain cases when the shortening muscle cannot safely be reached with the knife.

The change of position, or restoration of movement, is to be effected, under deep anæsthesia, by the judicious, yet resolute application of manual force. The object of the procedure is to break through the thickened tissue of perisynovial impediments, or of bands of adhesion, and also to rupture the shorter and thicker, impeding attachments of false anchylosis. If these parts be merely stretched, inflammation, or sometimes considerable pain without demonstrable inflammation, follows, and the operation will have been useless, or even injurious; but rent cicatricial bands very rarely inflame, especially if the rupture be complete. The surgeon's object should be effected by a series of jerks, carried out thus; the limb should always first be impelled in a direction opposite to that in which we wish to move the joint; for example, if we desire to flex a limb fixed in too straight a position, we first extend it still further, rupturing probably a few bands, and then flex it till a sufficiently decided resistance is encountered; next let the part recede a little towards extension, in order to gain a little impetus, and then by a rapid, but not violent, motion towards flexion, rupture the first and probably chief impediment. We press the limb again towards flexion until other obstacles occur, and repeat these manœuvres until all are overcome, or at least until all has been done that is considered safe and desirable. If any point has been, during examination, found to be painful in the way indicating the presence of bands of adhesion, it is well to steady the part during their rupture by pressing firmly with the thumb on the painful spot. But during this process the behavior of tendons and bands of fascia, and of cicatrices, must be carefully watched; should the former tighten sufficiently to evidently impede movement, they must be divided, while, if the hindrance come from scars, these must be separated.

The *after-treatment* must at first be directed to prevent or minimize inflammatory consequences: entire rest must be secured, and cold, in the form of ice-bags, should be employed. If merely change of position have been the object of treatment, rest may be maintained until completion of the case: if mobility have been aimed at, passive motion must be employed on the third day, unless some inflammation have set in. This must of necessity be to a certain degree painful; if too much so, an anæsthetic may be again administered, and indeed, if necessary, reiterated.

In the manipulation of each joint, certain methods of movement should be adopted, and certain precautions used, which need only very brief mention, because the above general directions give a great part of what is necessary.

SHOULDER.—*Method.*—One hand is placed with the palm on the acromion; the fingers and thumb grasp between them the head of the humerus. The first movement is to be rotation outward and inward, effected by holding in the other hand, the elbow bent at a right angle. The arm is then brought in front of the body till the elbow lies over the lower costal cartilages, and then it is placed behind the trunk. Afterwards, circumduction is used in an increasingly wide circle.

Caution.—By no means let the arm be abducted directly from the side at an early stage of the process, lest it be dislocated downward.

ELBOW.—*Method.*—The patient lying on the back, the surgeon places his foot on a stool, so as to bring his knee on a level with the mattress. He receives the elbow in his hand, placed upon his knee, grasping with his other hand the forearm just above the wrist. While bending or straightening the elbow, he must press his thumb on the head of the radius, forcing it to follow the direction of either movement. When bending and straightening are sufficiently free, rotation must also be employed. When, but this is rare, it is necessary to divide the biceps tendon, the arm must be straightened as far as it will go, and the skin-puncture must be on the inner side.

Caution.—The chief danger is luxation forward of the radius, if the arm be incautiously straightened; when the biceps is contractured, the thumb must be used as indicated. Rotation must not be practised by grasping the patient's hand, lest the wrist be sprained; but by grasping the carpus and lower end of the forearm. The biceps tendon must never be divided unless attempted extension cause it to start well forward, so as to permit its section without endangering the artery or nerve.

WRIST AND FINGERS.—*Method.*—Inflammations of the wrist-joint that result in fixity, involve the fingers by thecal adhesions; these should be dealt with first. The surgeon places his thumb on the front of the middle phalanx, so as to steady it, while with his index and middle fingers he bends the stiffened ungual phalanx, his own and the patient's fingers being at right angles to each other. He then goes through the same manœuvre for the second phalanx; to move the first, it is best to grasp the bone at its condyles. The bend should be sudden and complete, applied at first to each finger separately, and then to them altogether, clenching the whole hand. Afterward, the metacarpo-phalangeal joint must be circumducted. In dealing with the wrist, the surgeon grasps the lower end of the forearm in one hand, and the carpus and metacarpus with the other, using his thumbs to make pressure on any painful spots. After flexion and extension, rotation must also be made free.

Caution.—At this joint, more than at any other, pressure on painful spots with the thumb, is essential, to prevent subluxation of a carpal bone. It is especially necessary to proceed at this joint by a succession of short, sharp jerks, after the fingers have been freed.

HIP.—*Method.*—The malposture of this joint is nearly always a combination of flexion with adduction. The patient is first placed on the back; the limb is grasped at the condyles, and by a series of jerks is bent up till the knee is not far from the mammary region; then it is brought down, both feet being placed on the table with the heels near the ischial tuberosities, and the knees are separated as far as they will go; afterwards, the thigh, placed in medium extension (in a line with the axis of the trunk), is abducted; during this last movement, the adductors will resist; the adductor longus and gracilis, together with bands of the pubic part of the fascia lata, will start into strong relief; they may require division, of which hereafter. Afterwards, full extension is to be enforced.[1] If the bands of adhesion, or the anchylosis, be very firm, it may not be possible to obtain the necessary power while the patient is on a bed or table; he may then be placed on a mattress on the ground, and the thigh may be manipulated as in Bigelow's method of reducing dislocation. To obtain complete extension is often impossible while the patient lies supine and at full length on the mattress; he may then be drawn to the end of the table so that his ischia are at the edge, his sound leg being supported on a chair or by an assistant, while the surgeon presses the flexed thigh backward, taking care that the pelvis is properly fixed. Or the patient may be placed on his sound side, when the surgeon, placing one hand on the buttock, grasps the thigh at the knee with the other, and forcibly draws it backwards. These are the results which are aimed at, but I need hardly say that prudence generally renders it necessary to stop short of this ideal. Frequently, after a certain amount has been effected by operation, gradual extension, or a subsequent stretching, may enable us to gain a great deal more.

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[1] By this term I mean a position such that the knee lies posterior to the lateral median plane of the body.

Myotomy about the hip may be pretty extensively practised. I have frequently carried the operation very far, with excellent results; but, unfortunately, the ilio-psoas, which is the chief agent in maintaining flexion, is scarcely within reach of the tenotome. Certain structures that aid in keeping up that posture can, however, be divided, permitting force to be more immediately exercised on the contractured muscle. These are the iliac portion of the fascia lata, its tensor muscle, and the tendon of the rectus femoris. To divide the former, the surgeon should observe, while extension is exercised on the limb, the extent of subcutaneous section to be made. Let the limb be flexed enough to relax the skin, which is to be drawn from the flank as much as possible outwards; the tenotome is inserted a little below and internal to the anterior superior spine of the ilium, its point being directed outward, and, as it passes on, the handle is to be raised a little, so as to let the blade glide around, close to the bone, to the front and upper part of the dorsum ilii; the knife now lies between the bone and the higher portions of the tensor vaginæ femoris, and by causing the handle to pass in a semicircle downward, while the blade, taking the opposite course, is kept close to the crest of the ilium, the origin of the muscle is separated from the bone, while the thigh is extended as far as may be; afterwards, the edge is turned outward, towards the skin, and the fascia lata is divided, partly by pressing it down on the blade with the fingers of the other hand, partly by a sawing movement of the knife.

The tendon of the rectus femoris may be divided through a puncture either on its inner or its outer side; the latter is preferable. The skin should be shifted well inward, and the knife should be inserted about half an inch from, and a little below, the anterior inferior iliac spine; the blade must be sunk pretty deeply, and must go fairly under the tendon of origin; by carrying it upward while depressing the handle, that tendon is easily divided.

The adductors frequently require division;[1] sometimes only the superficial, sometimes the deeper ones likewise; the internal parts of the fascia lata must also in such cases be incised. The patient must lie on his back, and the limb be held in extension and in abduction sufficient to make prominent the tendon of origin of the long adductor, just outside of which the puncture is to be made. A rather stout tenotome being chosen, and the skin drawn well downward, the surgeon enters the knife a little outside that tendon, and so high that he feels the blade coursing along the surface of the bone. Turning the cutting edge inward, he not so much divides the tendon as peels it from the bone; this allows more abduction, and renders the gracilis tight, when its tendon is to be similarly dealt with. Now the fascia is found to be tight, not in one uniform plane, but in bands and puckerings here and there; these are also to be severed, but not very near the bone, especially in the male, lest the crus penis be wounded. The surgeon must now see whether the amount of abduction gained by the above sections is sufficient; if not, he must examine the state of the deeper adductors, which, if tense and firm, must also be divided. He takes a tenotome, with the usual length of cutting-blade, but with a blunt portion from $2\frac{1}{2}$ to 3 inches long; he introduces this at the same puncture, just outside the adductor longus tendon, and placing his left index finger on the anterior part of the tuber ischii, glides the blade downward (the patient being in the supine position), until he feels its approach through the skin. Now the edge is to be passed, close to the bone, towards the margin of the ischio-pubic ramus, withdrawing it slightly at the same time, so that, by successive acts of sweeping inward and withdrawal, the long and short adductors are in great part peeled away from the bone. In some cases, it will then be found that the pectineus causes obstruction, when its outer fibres, the chief impediments, may be easily severed through the same puncture.

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[1] There is a condition, much more common in the female than in the male, of shortening of the adductors, independent of any joint-disease. Such patients cannot separate the knees, which sometimes even cross. Difficulty in micturition without wetting the thighs, the impossibility of cleanliness, and at a nubile age other inconveniences, render operative interference essential to social life.

The operation completed, the patient is to be put to bed with the thighs well apart, and kept in that position by means of a sheet laid over them, with sandbags. If, previously, flexion was well marked, and has been with difficulty overcome, a firm, but not hard, horse-hair pillow should be placed under the buttocks. In some cases weight-extension may also be advantageously employed. Passive movement should commence early, if a movable joint be desired. It may, however, be necessary to repeat the induction of anæsthesia.

Cautions.—Such operations as these should never be undertaken too soon after the subsidence of hip-disease. When the original disease has been of long duration, and when there is demonstrably real shortening, with considerable projection of the trochanter, great caution must be used, since both the head of the femur and the acetabulum are probably much changed in form. To make sure that the pelvis is fixed, and does not follow the movements of the thigh, this must be more especially watched in extension (see page 384). In making sections of the muscles, the tenotome must be kept very close to the bone; if the division be made through the bodies of the muscles, some little distance from their origin, a good deal of blood is poured into the cellular tissue, and much ecchymosis of the inner part of the thigh takes place. This does not occur if the muscular origins be peeled away from the pubis and ischium.

KNEE.—*Method.*—The knee is commonly fixed in flexion; the muscles and fasciæ on the posterior part of the limb are shortened. The surgeon must first determine whether the patella is fixed to the condyles—generally, if at all, to the outer one; he must also ascertain if subluxation exists. If the patella be fixed by broad, bony anchylosis, the joint itself had probably best be let alone,[1] unless the surgeon is prepared to sever the patellar connection with chisel or saw; if it be attached by fibrous bands, these may be divided by a strong tenotome, passed carefully in the direction of the bony surface. This is best done by two punctures if the fixity be considerable and the attachments probably pretty wide; the one puncture should be at the upper outer, the other at the inner lower, edge of the patella; the knife from each should pass the whole length of the knee-cap, and should be carried obliquely inward and backward from the one, outward and backward from the other puncture, so that the two sections may meet in the position of the ridge that separates the two articular facets. After severance, the bone must be freely moved several times along over the parts beneath, to secure as much permanent mobility as possible. This operation should precede the main procedure by some days.

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[1] Another device of treatment will be mentioned hereafter.

To *bend a straight knee*, is an easier and simpler operation than to gain good position in the opposite direction, and it is not attended with the danger of subluxation. The most convenient method I find to be this: Place the patient on a narrow couch, or, if such be inaccessible, on the side of his bed, so that the part to be treated may be next the edge. Choose a block or stool of such height that when the operator's foot rests upon it, his knee shall be on a level with the surface of the couch or bed. When the patient is thoroughly anæsthetized, his thigh is abducted at the hip and is laid across the operator's knee, resting upon it as upon a support, with the part just above the popliteal space. By grasping the leg a little above the malleoli, the surgeon has now ample leverage, and by successive small but quick jerks may bend the joint with facility, unless the anchylosis be very firm. The advantage which the operator gains by using his knee as a support is, that it acts as a gauge of the power he is employing, and prevents its becoming excessive, while his position is mechanically favorable.

To *straighten a bent knee*, the patient may be placed in one of two positions: (1) he may be on his back upon a sufficiently firm couch or mattress, and a certain convenience is obtained if this be only just wide enough for the patient to lie safely—for instance, unless ample manual aid be forthcoming, it may be advisable to secure, with a broad strap, the patient's thigh to the bed; or (2) the patient, when etherized, may be turned over on his face. This posture gives to the surgeon certain mechanical advantages, as the front of the thigh, upon which the counteracting force falls, is supported by the mattress. The objection to this posture is that much more difficulty is experienced in accurately noting the effect produced; hence I greatly prefer the former posture. In either case, the thigh being well fixed by bands or otherwise, the operator first bends the knee still further, and then by a number of short, sharp jerks impels it in the direction of extension. Two points have in the mean time to be watched, viz., that the tuberosity of the tibia really follows the forward movement, and that neither rotation nor lateral movement of the leg or of the thigh is produced. Moreover, I would point out that it is often wise to abstain from pushing a first operation too far. These points will be further considered immediately.

After a certain amount of rectification, according to the case, has been gained, further advance is often prohibited by a peculiar, elastic, yet invincible, resistance; and, on placing his hand on the popliteal space, the surgeon will feel the hamstrings, and probably also the fascia, very tense. Nothing further can be effected till these are divided.

For division of the hamstrings, the punctures should never be made in the popliteal space, but at the sides of the limb, on the outer side of the outer, and the inner side of the inner tendons. The subcutaneous passage should be pretty long, and the section made towards the skin as near the tibial insertion as possible. In performing this operation on the biceps tendon, the fingers of the left hand should be well pressed in, close to that part, so as to separate it from the external popliteal nerve. Often a band of fascia running obliquely down the popliteal space must also be divided.

Cautions.—If the patella be inseparably fixed to the femur, the propriety of interference is more than doubtful, unless the deformity be very considerable. Mobility of the tibia on the femur, the patella being fixed, is nearly always disadvantageous, since the patient has very little control over the lower leg in the direction of extension; whence it becomes a very unreliable support. If the flexion be such as to make the limb a mere encumbrance, an attempt to straighten it may be made, the patient understanding that he will have to wear an instrument for probably some years. But before undertaking such an operation, the position in which the patella is fixed must be ascertained; this sometimes lies so low that, after very slight artificial straightening, the anterior edge of the tibia impinges against it. Such a mishap causes either cessation of further extension, or subluxation. In cases of considerable flexion, especially if combined with a certain amount of posterior malposition of the tibia, the great danger of efforts at straightening is the production of posterior subluxation. This danger is due partly to tension of the tissues behind the joint, but chiefly, I believe, to shortening of the anterior crucial ligament, which does not allow the upper end of the tibia to glide forward on the condyles during the act of rectification. When the slightest signs of this tendency appear, or, in other words, when the parts below the patella appear, while the leg is straightening, to become hollow instead of fuller, the movement must at once cease. Perhaps a little may still be gained by forcible downward traction from near the malleoli, or something further may be effected by placing a firm block behind the calf, and making pressure backward on the lower third of the thigh. Then the limb should be put up in plaster of Paris, and after a week or ten days another effort may be more successful.

In cases which have been preceded by long disease, it is necessary to be cautious lest so much of the anchylosing tissue be torn that not merely antero-posterior, but also lateral mobility may be produced. When tenotomy is practised, the punctures must not, as I have said, be in the popliteal space; this is to obviate a rent of the skin across the back of the joint, but it must be remembered that, if flexion be considerable, this may occur, even if there be no wound, especially if there be several cicatrices in the neighborhood. Deeper parts, such as the artery, have also been torn by too energetic surgery.

Ankle.—*Method.*—The ankle is often stiffened by tendinous or perisynovial adhesions, which may, as a rule, be overcome with little difficulty; but when fixity results from firm bands, or false anchylosis in the joint itself, the condition is very refractory, because the astragalus is so short, and because the tarsal articulations lie so near the ankle-joint, that it is not possible to get an advantageous hold on the bone. If the joint be so fixed that the foot lies at a right angle to the leg, it is better not to use much force to break down the bands; the other joints become, after a little time, so flexible that immobility between the tibia and astragalus produces but little inconvenience.[1] But if the foot be considerably extended, more potent efforts are not merely justifiable, but desirable. In order to obtain a firmer hold, I am accustomed, in bad cases, to mould upon the sole a stout piece of poro-plastic felt, and to encase the foot in plaster of Paris and gum, taking care to leave space below and in front of the malleoli for flexion. A day or two after, the tendo Achillis is divided, and then with one hand at the heel, the other at the anterior part of the foot, flexion is carried out; but it must be remembered that, even with this contrivance, much of the force must fall on the calcaneo-scaphoid joint. Considerable power may be used, but I am bound to say that, if the false anchylosis be close and firm, even great force may fail.

Cautions.—No other tendon than the tendo Achillis should be divided; none other is attached behind the ankle-joint, and nothing is gained by cutting others. It is imprudent to exercise much force without some such means as that above indicated, lest injury be done to some of the other joints, especially to the medio-tarsal. In case the deformity be distressing, and all justifiable efforts at restoration have failed, the patient should have the option of undergoing a larger operation, such as that of partial excision.

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[1] The mobility of the tarsus is so considerable that fixity of the ankle-joint itself is not always easily diagnosed; if, however, the finger be pressed deeply in between the tip of the internal malleolus and the tibialis anticus, while an assistant alternately flexes and extends the foot, the head and neck of the astragalus will be found to move or to remain at rest according as the ankle-joint is free or anchylosed.

True anchylosis of either *hip* or *knee* may occur in such a flexed position as to cause the limb to be very useless, and the patient to be exceedingly lame; a contrary condition at the *elbow*, viz., a straight anchylosis, renders the limb of very little value. Thus the question as to treating a true anchylosis must depend upon the amount of inconvenience produced. It must be remembered that a movable joint cannot be secured;[1] the question is only that of placing a motionless one in a better posture.

True Anchylosis of Elbow.—An elbow anchylosed in a straight position may be placed rectangularly by dividing the humerus just above the joint; the part of the bone which lies between the olecranon and coronoid fossæ is very thin; all that is needed is to divide the two divergent pillars of bone that adjoin these fossæ on either side, but, owing to the position of the vessels and nerves, the operation requires some little care; it is best effected through two incisions, just large enough to admit a chisel one-third of an inch broad. The outer incision is made upon and a little behind the condyloid ridge, the chisel being driven inwards and a little forwards. The inner opening is made upon and rather in front of the internal condyloid ridge, and the chisel is directed outward and a little backward. The bone on each side is cut to about the depth of three-fourths of an inch, when the rest is easily snapped. The arm is now, while extension is kept up, to be bent to a right angle; to the outer aspect of the upper arm and to the back of the forearm, are to be secured, by plaster-of-Paris bandages, two gutters of metal, short enough to leave between them at the elbow a considerable interval which is bridged over by brackets standing well away from the limb, so as to allow of separate dressing of the wounds, without disturbing the position. The arm with this appliance is to be slung by pulley and counterpoise. The wounds should be healed in about a week, and the union should be fairly firm in a month; but a light retentive splint should be retained for some time longer.

[*Excision of the elbow* has been occasionally practised in these cases with the view of obtaining a movable joint. P. H. Watson and Annandale prefer partial to complete excision, and remove merely the lower part of the humerus.]

True Anchylosis of Hip.—When the thigh is bent at the hip-joint at an angle of 135°, and *a fortiori* at a less angle, the greatest inconvenience and lameness are produced, for the relief of which several operations have been devised and practised. To Dr. J. Rhea Barton, of Philadelphia, belongs the honor of the first attempt to rectify by osteotomy, in 1826, an angular, true anchylosis of the hip-joint; he sawed through the femur between the trochanters, bringing the limb into a straight position, and giving his patient a joint which continued movable for several years. Dr. J. Kearney Rodgers, of New York, modified this operation in 1830, by removing from between the trochanters a disk of bone. In 1862, Dr. Lewis A. Sayre divided the femur above the small trochanter, and removed a semi-globular piece of bone, with the intention of forming a new socket in which the truncated shaft might play.[2] In 1869, Mr. Adams sawed through the neck of the femur.[3] In 1872, Mr.

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[1] If ever such an event has occurred, it is so very exceptional as hardly to affect the question of practical prognosis; the advantage, too, could only be very doubtful, since muscular attachments are only planned for movement in a certain locality, and movement elsewhere would be more or less out of control.

[2] Lectures on Orthopædic Surgery, etc., p. 423.

[3] A New Operation for Bony Anchylosis of the Hip-Joint, 1871.

Gant divided with a saw the thigh bone a short distance below the small trochanter.[1] In 1873, Volkmann introduced another method, removing a wedge from the outer part of the femur, and breaking the rest. Lately he has followed another more complicated procedure.[2] In 1879, I used the chain saw to divide the bone above the great trochanter, modifying Sayre's operation.[3] Of these operations, most have been repeated: Sayre's, I believe, only by himself; Adams's, by many operators; Gant's, by Dr. John Ashhurst and others; Volkmann's, only, as far as I know, by himself; my own, by myself and Mr. Cantlie.[4] [The late Mr. Maunder divided the bone below the lesser trochanter with a chisel.] A rather more detailed account may be given of these various procedures.

Dr. Rhea Barton made a rather large external wound, and simply divided the bone between the greater and lesser trochanters. In his modification of the operation, Dr. Kearney Rodgers took away a disk of bone, half an inch wide at its outer and three-fourths of an inch at its inner side. Dr. Sayre thus describes his operation:—

> "An incision of about six inches was made over the trochanter major. The cut was slightly lunate, with the concavity looking downward. The lips were then separated, and the deeper structures, including the periosteum, were detached from the bone. A curved instrument armed with the chain-saw was passed around the bone, between the trochanters, and the femur first sawed transversely across. A roof-shaped piece was then sawed out of the upper fragment. In my second operation I sawed the curved section first, and should advise the operation to be performed in that way."[5]

Mr. Adams calls his operation subcutaneous; a claim which, considering the in-and-out movement of the saw, cannot be conceded. It is an osteotomy with a small wound, and is thus performed:—

The instruments necessary are a knife in the form of a tenotome, but with a very long, rounded or blunt portion, and a cutting blade of a little over an inch long; also, a saw, constructed on the same model. Both these are provided with large, firm handles, usually pistol-shaped. The knife, introduced above and in front of the great trochanter, is carried downward and backward till it incises the periosteum and impinges on the bone; it is then withdrawn, the saw is substituted, and this works until the cervix femoris is severed. The tensor vaginæ femoris, the upper tendon of the rectus, and any other accessible resisting parts, are divided, and the limb brought down straight.

Professor Volkmann's method, first practised by him in 1873, is to make a rather long incision along the posterior edge of the great trochanter, to peel the periosteum from the junction of the neck and shaft as far as he can reach around the bone, to cut out with a gouge and chisel a wedge-shaped gap, and to fracture the rest; the femur is then brought down straight, and allowed to unite. His twelve patients all recovered with useful limbs.[6] Lately he has introduced another method, whereby he hopes to obtain mobility at a new joint, which he endeavors to form by adding to the former procedure gouging out of the head and the remaining neck, rounding off the truncated shaft, and placing it in the reproduced cavity. Six patients thus operated upon by Volkmann are reported to have recovered with some flexibility at the false joint.[7]

My own operation is facilitated by the use of an instrument made on the model of a Bellocq's sound, but larger; the spring, which is sharp at its extremity instead of probe-pointed, can be entirely withdrawn from the canula. From near the top of the trochanter, downward on the outside of the limb, is made an incision 1½ inches long, and extending down to the bone. Across the centre of this, another incision, equally deep, and slightly exceeding at either end the breadth of the bone, is drawn. The periosteum is now peeled away from both back and front of the bone, and as far as possible to its inner side. By passing the finger into the depth of the wound, behind the femur, the surgeon now can feel the small trochanter and the ilio-psoas tendon, above and outside which is a space bounded further out and higher by the curved femoral neck. The instrument above described is taken in the other hand and passed in front of the bone, and thence around it, until the finger-tip feels the end of the tube present itself in this space; the spring being protruded, now passes behind the bone, comes into sight, and is withdrawn, bringing with it a strong silk ligature which, in its turn, carries around the bone a chain-saw, with which the junction of the neck to the shaft is severed. In my cases I have found no occasion to divide the soft parts, either muscle or tendon, but have been able to bring the limb into position after some little traction. In the after-treatment the thigh should be much abducted, so that the necessary parallelism of the erect posture may cause depression of that side of the pelvis, thus compensating for the unavoidable shortening (see page 383).

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[1] Science and Practice of Surgery, vol. ii. p. 49.

[2] Beiträge für Chirurgie, S. 230.

[3] Clinical Society's Transactions, vol. xiii. p. 421.

[4] Dr. Ashhurst performed, on the same patient, Adams's operation on one side, Gant's on the other; [he has also operated, by one or other of these methods, in six additional cases, and in every instance with a satisfactory result.]

[5] Op cit., p. 427.

[6] Gross, System of Surgery, 6th ed., vol. i. p. 1095.

[7] Ibid.

Of these various methods the following must be said: It is of doubtful advantage to aim, by removing portions of bone, to procure a false joint. It certainly is very questionable whether a greater prospect of mobility is attained by such removal; it is probably the after-treatment rather than any other factor which determines the condition of mobility or the reverse. Nor is a joint, in the usual acceptation of the term, attainable; if such could be formed, it would not, I believe, be a very reliable support, since muscles are placed to maintain posture, or confer movement, at a particular part of the skeleton, and we cannot by art transfer the functions to another part. A firm, fibrous union, if strong enough to support the weight, yet flexible enough to permit some movement, would be useful; but, as said above, this is unattainable by removing portions of bone. Nor does experience show that the mobility, verified shortly after the operation, is persistent; the tendency has always been towards complete stiffness.[1]

Thus, the method of Sayre and the second method of Volkmann I take to be unnecessarily severe, and in so far (Volkmann's certainly) unnecessarily dangerous.[2]

Gant's operation appears to be the mitigation of one deformity by the substitution of another; for the upper fragment is of considerable length, and, if the hip be flexed at an angle calling for operative interference, for instance, at something like a right angle, that fragment must protrude greatly, and the whole of its length be lost to the limb. [The Editor's experience with Mr. Gant's operation has led him to form a more favorable opinion of it than that expressed in the text. The bone-section being made but a short distance below the lesser trochanter, the projection of the upper fragment is inconsiderable, and the slight shortening is readily compensated for by the adaptation of a high-soled shoe.][3]

Adams's operation, division of the neck of the femur with a saw, is very valuable whenever the surgeon can be sure that a sufficiently long neck exists. It is inapplicable to most cases of anchylosis occurring after hip-disease, by which the neck of the femur is greatly altered—sometimes almost entirely absorbed (see page 385). There is, after the operation, considerable difficulty in bringing the limb down, and it would appear that in some cases very considerable division of the soft parts is necessary.

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[1] Such phrases as, "when last seen some mobility still remained, but was decreasing," are usual in the history of these cases.

[2] Volkmann considers that, in children, simple section, without removing any bone, may suffice.

[3] [An interesting study of this subject has been published by the Editor's colleague, Dr. H. R. Wharton, in the American Journal of the Medical Sciences for July, 1883.]

My operation is modified considerably from Sayre's, both in the shape of the external incision and in the direction of dividing the bone, which is obliquely upwards and outwards. I have performed it three times; Mr. Cantlie once. The limbs in the successful cases became very useful, and by keeping them well abducted during the after-treatment, they were, though shortened by actual measurement, but little shortened in appearance when the patients stood. The operation is by no means severe.

The statistics of several of these operations are as follows:—

	Cases.	Deaths.
Barton's and Rodgers's operations	15	6
Sayre's operation	2	1
Adams's operation[1]	33	3
Barwell's operation	4	1[2]

True Anchylosis of Knee.—When a true anchylosis of the knee occurs in a straight line, or indeed at any angle more than 145°, it should probably be let alone; but if the angle be more acute, that is about 135° or less, the inconvenience is very considerable; moreover, the position in walking and standing is so bad that in young persons scoliosis is pretty sure to be produced. The choice of procedure ordinarily lies between two methods, for I assume that the plan practised by Dr. Gurdon Buck, of New York, and by Sir Wm. Fergusson, of excising a large wedge of bone from the angle, would now not be employed, or even come into question, save in exceptional cases; and a like observation may be made concerning Rhea Barton's method of sawing a wedge of bone from the front of the femur a short distance above the condyles; both operations are unnecessarily severe.

Brainard's suggestion (1854) of boring through the femur several times with a drill,[3] and fracturing the bone, was in Pancoast's and Agnew's cases followed by severe suppuration. Brainard, in 1860, modified this proceeding, by perforating the femoral condyles themselves. These piercing and fracturing operations have been performed, as far as I can gather, seven times, with one death, but suppuration was frequent. In 1861, Professor Gross, of Philadelphia, extended the use of the drill to the anchylosing bone-substance itself, using a perforator one-sixth of an inch in breadth, and coming to a triangular or diamond-shaped point. This weapon he passes in different directions into the interval between the femur and the tibia, breaking down the intervening bone-tissue, or, if this be too firm, completing the section with a narrow chisel or Adams's saw. Seven cases, five of which were his own, have done well under this treatment, and in only one was the traumatic fever somewhat alarming.[4] Dr. Gross points out that the operation is dangerous unless there is complete true anchylosis.

In 1875, I was, I believe, the first surgeon to use simple osteotomy above the condyles for the relief of angular, true anchylosis of the knee. Whenever the leg lies at less than a right angle to the thigh, division of the tibia also is probably desirable in order to obviate deformity and inconvenient projection of the knee. I performed the double operation for a rectangular anchylosis some years ago, but believe that it is not necessary in all such cases if the subject be young; when the angle is acute, it will probably be desirable. The effect of division of the femur alone may first be tried, and, if replacement cannot be thus effected, or if it produce great tension of the skin, or sufficient pressure on the popliteal artery to sensibly affect the pulsation of the tibial vessels, the limb may be left at an angle of 135°, and complete rectification afterwards procured by division of the leg-bones.

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[1] Some of these with much suppuration and prolonged convalescence.

[2] My fatal case was that of a girl aged 14; a small portion of the lower segment became necrosed; the sequestrum could easily have been removed, but her nearest relative (uncle) declined to have anything done, would not even allow a resultant abscess to be opened, encouraged the child in recalcitrance, resistance to being dressed, etc. Her death is only attributable to obstinacy and indocility.

[3] The use of a chisel and mallet to the anchylosed joint had been previously suggested by Malgaigne.

[4] Op. cit., vol. i. p. 1099.

The method of operating on the femur is this: For osteotomy of this description the surgeon requires, of peculiar instruments, merely a small mallet of some rather heavy wood, such as *lignum vitæ*, and a chisel. This latter must not like an ordinary carpenter's chisel be bevelled to the cutting part entirely from the face, but from both back and front, so that the lateral border is lancet-shaped. Two very important points the surgeon must test for himself, since instrument makers are much inclined to go wrong. The blade must not get thicker or broader above the bevel, since, if it do so, it is sure to get jammed while cutting the bone; indeed, if any difference in thickness may be allowed, the maximum should be just where the bevel begins. My chisel has these dimensions: At the lower, the cutting end, it is $\frac{9}{16}$ inch broad and just over $\frac{1}{16}$ inch thick. At the upper end it is $\frac{1}{2}$ inch broad and a shade less than $\frac{1}{16}$ inch thick.

When fully anæsthetized, the patient is to be placed on his sound side,[1] and the limb of that side is to be drawn down quite straight, at both hip and knee. The other limb is bent, crossing over the sound one so that the inner condyle rests on a small bag of slightly moistened sand, which gives sufficient resistance to let the mallet-blows tell, and yet does not bruise the part lying on it. The ridge on the condyle which separates the articular facet from its outer lateral surface should be made out; a line or two above this is the most convenient place for operating.[2] A scalpel, with the edge looking forward, is passed through all the soft parts to the bone; the skin is best divided by pulling it backward with the other hand against the blade; by moving the point forward, well pressed against the bone, the periosteum is incised. Taking the chisel in the other hand, the surgeon slides it along the flat of the knife, still kept in place, until it is felt to come in contact with the bone, which must necessarily be at the periosteal wound. Now the scalpel is withdrawn, and by taps of the mallet, gentle at first, the instrument is made to bite, that is, to sink into the bone so deeply that it supports its own weight; after this, the mallet-blows may be a little heavier. By this means the chisel is driven in various directions into the bone, taking care between every four or five mallet-taps to loosen the instrument by moving it sideways, that is, across the axis of the bone, not up and down. Sometimes, in spite of all care, the chisel may get jammed sufficiently to require some force in loosening it, and in doing this it may be pulled a little too forcibly, and come out of the osseous wound. When this happens, it is very essential to make sure of its re-introduction into the same slit, as otherwise a thin shaving of bone might be severed, which would be very likely to become necrosed and set up suppuration. Thereupon the chisel should be quite removed, when the eye-end of a silver probe may be passed into the flesh-wound, and gently moved up and down till it falls into the osseous gap; along this the chisel is to be guided into its proper place, and the cutting may then recommence.

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[1] I prefer operating from the outer aspect of the thigh.

[2] Even although disease have obliterated this ridge, there will be no difficulty in fixing the spot above indicated.

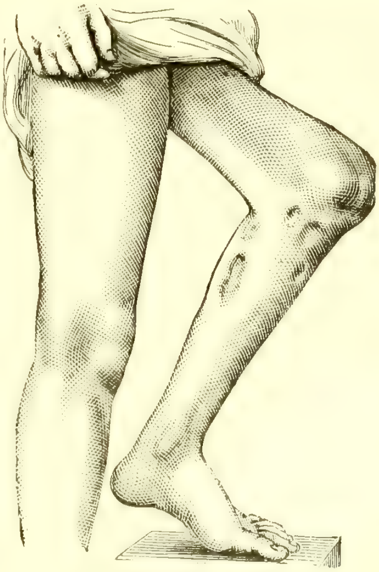
The operator must carefully watch the direction of his chisel, and the depth to which in various positions he has sunk it; and so must cut through, or very nearly through, all the circumference of the bone except at its posterior part, very near to which lies the artery. This part is to be broken by giving the leg a quick but not violent jerk, in the direction of flexion.

Extension, combined with traction, may now be employed to bring the limb either straight or half-straight, according to the directions above given, and while it is held in this posture, a plaster-of-Paris bandage is applied and allowed to harden, the greatest care being taken in regard to position, not merely as to the degree of extension, but also as to the position of the foot. Rotation of the tibia on the femur not unfrequently occurs during knee-joint disease; osteotomy affords an opportunity of correcting it.

Nothing has as yet been said about dressing the wound, because on that subject, and on the desirability or otherwise of the spray, etc., I wish to say a few words. A year or two ago, I used to perform all my operations under the spray, and dress the wound with all the Listerian complications. I never do so now, and I believe that the wounds heal more quickly, and certainly the patients have less pain. Under Listerism, the many folds of gauze make a great lump at the place of operation, and this renders it rather difficult to judge of the symmetry of the limb. Also, a window has to be made in the plaster-of-Paris case, for removing the drainage-tube and redressing the wound. I now treat my cases on a less complicated system. Immediately after fracture of the bone, the wound is syringed out with a saturated solution (five per cent.) of boro-glyceride; a few strands of catgut are introduced about half an inch into the wound, to act as a temporary drain; a thin pad of cotton-wool, soaked in the same fluid, is laid over the wound; through the middle of this pad is placed an India-rubber tube, one-eighth of an inch in diameter, and two or three inches long; the plaster-of-Paris bandage is then applied, but, when it reaches the level of the wound, a piece of copper tubing is slipped over the India-rubber, so that it may not be compressed and thus rendered impervious. I call this my irrigation-tube; through it I inject, with an ordinary glass syringe, about a drachm of solution of boro-glyceride, daily for the first three days, afterwards only occasionally. Since I have devised this method, I have never seen the wounds, but I believe that they have all healed in about six days. This plan is a great saving of time and trouble to the surgeon, and saves pain to the patient, since in using the Lister method, a window has to be made some time during the first week, and it is just during this period that, although while the limb is still it is quite comfortable, movement gives a good deal of pain.

To place entirely straight, after simply dividing the femur, a knee which has been fixed at an acute angle, is rarely wise (see p. 416); even if all danger of gangrene from compression of vessels be disregarded, and though we may feel sure of firm union, yet the subsequent pain, for a certain period, is the more severe and the more prolonged, the greater the change in

Fig. 670.

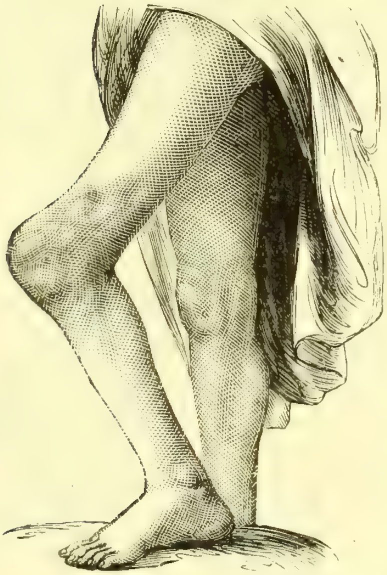


True anchylosis of knee.

the posture of the lower femoral fragment. It is better, therefore, to let from a month to six weeks, according to the age of the patient, elapse, and then divide the leg-bones.

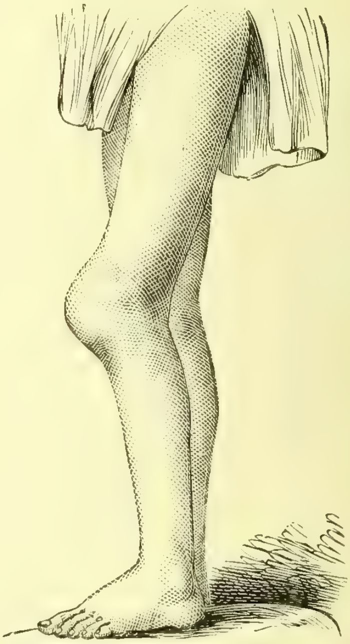
It certainly is better to divide both fibula and tibia, rather than the tibia alone, while fracturing the former by mere manual force. Just a little below its head, the fibula dwindles down into a very thin neck. Choosing a spot just below its head, and a little behind the bone, the knife is sunk and the chisel glided down to it; two or three taps with the mallet will so far weaken it that it may readily be broken by pressure with the thumb. The surgeon now finds a place on the inner posterior edge of the tibia, on a level with the lower part of the tubercle; here the head or tuberosity of the tibia ceases and the shaft begins. It is almost subcutaneous, so that the knife followed by the chisel reaches the bone very easily. From this point it is driven in a direction forward and a very little outward; then, being almost withdrawn, it is directed more backward, but still outward and a little forward. A very slight backward twitch will fracture the rest, the knee and recent line of union of the divided femur being held firmly. The same bandages and modes of dressing are used as after the previous osteotomy.

Fig. 671.



True anchylosis of knee after division of femur.

Fig. 672.



The same limb after division of tibia and fibula also.

This mode of treating anchylosis is very successful and extremely satisfactory. Very remarkable is the slight amount of deformity left by an operation which must bend a bone, normally straight, at a very considerable angle. Let us, for instance, assume that a knee is anchylosed at a right angle; the femur is divided and the tibia brought to lie in a line with the femur.[1] To effect this, the bone must be bent at a right angle at the place of section. At first (as in Fig. 672), a considerable inflection is perceptible, but

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[1] Strictly, in a line parallel to a prolongation of the axis of the femur.

in a month or two the divided bone appears quite straight; the entering angle, the soft parts being lifted away, appears to become filled up, and the salient angle, pressed up by soft parts somewhat stretched, to become absorbed. Thus the ultimate result—that is, about four months after the photograph was taken—showed in this case of double osteotomy a straight limb without deformity of either segment.

Under certain unusual conditions osteotomy might be required at the *shoulder* (upper end of the humerus); or at the *ankle* (lower end of the tibia and fibula), for anchylosis of the foot at an awkward angle.

Neuroses of Joints.

(*Hysterical Joints.*)

The nature and pathology of hysteria hardly lie within the scope of a surgical work; but I may be permitted to say that the name is somewhat unfortunate, because, first, although chiefly manifested in, it is not absolutely confined to, the female sex; and because, secondly, it frequently occurs without owing its origin in any way to the uterus or other genital organs. Nevertheless, the malady is most common where some cause of uterine irritation may be traced. Thus, certain women are always hysterical when pregnant, and never at other times; some are hysterical just prior to the appearance of the catamenia, the symptoms ceasing when the flow is fully established; some prostitutes are always strongly hysterical. These instances furnish distinct evidence of genital irritation; but the larger number of cases, though not as a rule the more violent ones, are furnished by unmarried maidens, between the ages of 17 and 30, and in a goodly proportion of such cases amenorrhœa, dysmenorrhœa, or a slight degree of menorrhagia, is present. Sometimes ovarian pain, in all probability produced by congestion, can be detected; and, in many cases, there is a history of misplaced or disappointed affection. But, on the contrary, many hysterical persons have no uterine malady whatever, nor, as far as can be ascertained, any disappointment. Both women and —but far more rarely—men, reduced by long and wearing disease, may be affected by that form of causeless, or almost causeless, weeping, which we call hysterical.

The forms which hysteria takes are two—viz., hysterical paroxysm and mock disease. The two are rarely coincident and simultaneous, but the latter not unfrequently succeeds the former; and I have known a good strong fit to dispel most obstinate articular and spinal hysterical neuralgia.

Although no period of life, after puberty, is exempt from liability to this neurosis, yet there are some differences and peculiarities at different ages. Young women—that is, from 17 to 25—are more subject to the paroxysmal form. After 25 (unless in pregnancy) the tendency is more towards mock disease. If at the younger age some local malady be simulated, it is rather more commonly of the spine than of a joint; and if of a joint, the hip is most usually affected. Again, the hysterical neuralgia of the young is of an acute kind—the pain is described as "horrible," or "awful;" that of the more mature has the characters of a chronic disease.[1]

A peculiarity of all hysterical symptoms is this: That any moderate excitement or shock, whether of joy or grief, may excite or bring them on, whether previously quite absent or merely slight. But a violent shock, as terror, horror, or the necessity of escape from imminent danger, often banishes the malady suddenly, at least for a time. One of the mental states which seems most frequently thus to influence the neurosis is religious fervor and excitement, combined with the presence of some visible or tangible object of faith. Many, indeed the majority of patients, have a certain control over their pains and troubles—can either repress or aggravate them—and they are themselves more or less conscious of this power. If by the indulgence of compassionate but over-anxious friends they are encouraged to make the worst of their pains—to fret over and nurse them—they will almost inevitably get more severe; while a firm but not unkind ignoring, or at least not fostering, of their troubles, tends greatly to their alleviation.

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[1] Numerous exceptions to these aphorisms occur. The malady is protean, and it is only possible, in so variable a disease, to indicate the prevalent conditions.

SYMPTOMS.—Very rarely are any joints attacked with hysteric neuralgia, save the hip and the knee. Three points are more especially characteristic, viz., absence of inflammation or swelling, presence of much pain with extreme surface tenderness, and anomaly in location.

In regard to inflammatory signs and swelling, their absence must not be taken as absolute, for occasionally a slight redness and a very little swelling may be detected; but not at first, only after the pain has lasted some time. The *redness*, if it occur at all, is evanescent, and in some cases vanishes a few minutes after the part is exposed to the air, and perhaps may return again before the examination is over; it certainly seems to me to come on when the patient's attention is strongly fixed on the part. The *swelling*, if present, is merely dermal; it may be moved over the subcutaneous parts, and therefore, though visible to a trained eye, can hardly be felt or verified by tape measurement. *Heat* is absent, unless it have been artificially produced by rubefacients or by warm coverings to the limb. The fourth symptom of inflammation, *pain*, is abundantly present, according to the patient's account; and in consequence of this pain she declares herself to be lame.

Now, since all signs of disease except pain are absent, or only very slightly marked, it follows that any conclusion as to the disease is chiefly to be drawn from studying the accounts which the patient gives of that symptom. In this study, some little management and tact are necessary; when, for instance, a girl or young woman between the ages above specified, complains of a joint, which, without sprain or other traumatism, without rheumatism or cold, has become rather suddenly painful, the surgeon, without prejudging the case, should have in his mind the possibility of hysterical neuralgia; having ascertained the history, whether or no the uterine functions are well performed, and whether the suffering increase about the catamenial periods, he may let the joint be uncovered, and, looking at it a while, may very gently brush his finger-tips over the surface. If this act cause a start, and an expression of pain, his suspicions will be much confirmed. Afterwards, the patient may be questioned as to the painful localities; these will nearly always be found to differ from those of real disease. Moreover, if the flat hand be laid very gently on the spot indicated, and then the pressure be slowly increased, even until it is pretty considerable, it will be found that the heavier is better borne than the lighter contact. The joint-surfaces may be pressed, even jarred together, without eliciting any complaint, as long as the superficies of the joint be not touched, more especially if the patient be made to believe that an examination of some other part of the limb is being made. In some cases, movement is painless, and occasionally free within certain limits; in other cases it is resisted by voluntary or emotional muscular contraction, the signs of which are evident to both eye and hand. But—and this is an important circumstance—movement produces in many hysterical joints a fine, slight crackling, which might, unless the fact were known, mislead diagnosis; it is to be remembered that certain joints of persons between fifteen and eighteen, the age of greatest growth, habitually crepitate in this manner. A coarser crackle may sometimes be detected in old long-standing cases of hysteric malady, more especially in such as have been treated as though affected with real disease. Moreover, the limb segment above the joint does not waste; it is true that if the patient have been long laid up, and have not used the limb for some time, it may be slightly smaller than the other, but not in the same way or degree as in organic joint-disease. The flexors are not tighter nor harder than the extensors; usually, indeed, the latter are the more contracted. These points should be examined in two ways: the one, while the patient's attention is fixed on the joint; the other, while it is, as far as possible, diverted by conversation in some other direction, when the formerly rigid limb will often be seen to relax, or the previously very sensitive joint may be touched with impunity.

Certain points of difficulty arise when the hip is the affected joint; but some astuteness in the method of examination will eliminate them. The patient being probably in bed, the posture (lengthening, shortening, and flexion) is to be visually noted. If, now, the hand be passed gently over the region of the great trochanter, great manifestation of pain will occur; if the surgeon take the knee, and endeavor to move the femur, it will probably be rigid; but rigid by means of great tightening of muscles—the thigh and nates may be felt hard and resilient. Nevertheless, if the limb be watched during subsequent procedures, it will not be found to maintain a constant angle with the pelvis. Very often, if the patient's attention be directed quite otherwise, one may, by grasping, not the thigh or knee, but the foot, place the limb, unsuspected by the patient, in various different positions, without moving the pelvis. The first posture-symptom of true hip-disease is nearly always that of lengthening; in hysteric hip, the first change, if any, is that of shortening, in the great majority of instances; but it is excessive in regard to the other symptoms, while some parts of the posture itself are exaggerated; the buttock is thrown too violently back, but the nates, instead of being loose, are tense, and have not that increased breadth characteristic of the real disease in this stage. The spine is also excessively curved and twisted. Very often the patient stands thus, but with the foot lifted from the floor—a position which I once saw in sacro-iliac disease, but have never seen in hip-disease. If the patient be left standing, with some such support for the arms as the back of a chair, and if other conversation be introduced, one sees, as fatigue begins, the malposition gradually grow less; but if a word be said shortly and sharply about the change, it will almost suddenly return in its former intensity. These signs may not all be present in any one case—a peculiarity of hysteria is variability—but some of them will exist, while the limb-wasting is invariably absent.

While wishing to emphasize the necessity of examining the patient so as to put her off her guard, I would also deprecate any questions or observations which might indicate to her the true symptoms. The most difficult cases are those which have been already submitted to much examination, which has enlightened the patient; especially difficult, both to recognize and to cure, are such as under mistaken diagnosis have already been treated for a considerable time by the use of splints, rest, blisters, etc.

Treatment.—A very great part of the management of hysteric joint-disease must depend on the absence or presence of any uterine affection; dysmenorrhœa and amenorrhœa must of course be treated according to their cause; menorrhagia, or, which is more common, slightly excessive and too frequent menstruation, should at once be stopped by the use of such astringents as gallic acid, or, which generally answers the purpose, of the Indian hemp. But if no uterine trouble be traceable, it is, I believe, a mistake to give emmenagogues or other medicines directed to the womb. As a rule, under these circumstances, aloes and iron, myrrh, etc., tend rather to increase the trouble by augmenting the pelvic, and therefore the ovarian hyperæmia.

Certain remedies are frequently valuable, their use being guided by the robust or anæmic condition of the patient; in the latter condition, iron (without aloes) may be advantageous. With this remedy, alternating with quinine, strychnia, or other bitter, valerian or valerianate of zinc, or bromide of potassium, may be combined. Bromo-camphor is doubtless also capable of yielding good results. In the robust, the applicability of tonics is more than doubtful, especially of iron, aloes, or any medicine which may produce hyperæmia of the pelvic organs. Local treatment, such as is applicable to inflammatory joint-disease, is only hurtful in the mock disease. The utmost to be done in this direction must be the use of a chloroform or belladonna liniment, and even this as a rare exception, since whatever calls attention to the part must be avoided; yet sometimes a little yielding to strong imagination must be conceded.

I have had occasionally very marked success by the contrary device, viz., by attracting the patient's attention to another part. Thus a little seton may be passed subcutaneously a good way from the seat of disease, particular directions being given as to the method of managing and dressing it, with some little mystery about its use, and the assurance that when the thread comes away the limb will be well. In one case that I saw, the girl had been told that her knee must be excised, and on this she had fixed her mind; the case was most obstinate. At last chloroform was given, and a longitudinal incision made through the skin on each side of the joint; it was put up in splints, she firmly believing that some severe operation had been practised. In about a month, when the wound had healed, the neuralgia ceased. A year ago I treated a young lady in this way, but made a smaller cut on the outside of the joint; she also got quite well. There are other ways in which the imagination may be used—and often by designing persons misused. Entire and implicit trust in a certain set of remedies, or even in a certain person, or, as has more than once happened, in a certain spring or relic, has cured hysteria which has resisted all other means.

In the worst cases, the plan introduced by Dr. Weir Mitchell[1] may advantageously be employed.

ARTHROPATHIES FROM INJURIES AND DISEASES OF NERVES AND OF NERVOUS CENTRES.

Diseases of joints consecutive to and produced by morbid conditions of nervous trunks and centres, form a subject still full of obscurity and difficulty, although of late years much light has been thrown on the subject, in one particular direction, by the labors of Charcot, Weir Mitchell, Ball, Westphal, and Buzzard.

The first step in this direction was, I believe, taken by J. K. Mitchell, of Philadelphia,[2] who, observing a remarkably obstinate case of acute or subacute rheumatism in a woman with angular curvature, resolved, after the failure of all the usual remedies for rheumatism, to treat it as due to spinal irritation or inflammation. His measures were rapidly successful. He afterwards treated three other cases of rheumatism on the same principles. Their success led him to conclude that rheumatism was a spinal neurosis, and his theory met with a certain support; nor is it at the present day forgotten or negatived. Whether this view of rheumatism can or cannot be maintained, it is evident that the doctrine of a neuropathy producing an arthropathy was here distinctly formulated.

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[1] Lectures on Diseases of the Nervous System, especially in Women. Philadelphia, 1881.

[2] On a New Practice in Rheumatism. Am. Jour. of the Med. Sciences, O. S. vol. viii. p. 31. 1831.

In 1846, Dr. Scott Alison read, before the Medical Society of London, a paper on arthritis occurring in the course of paralysis.[1] Two cases are described, the patients in both having been perfectly healthy until attacked by hemiplegia; in both, after a few days, certain joints (wrist, knee, foot) became swollen and painful. Both patients died; and it is much to be regretted that, although autopsies were made, the joints do not appear to have been examined. A case recorded by M. Viguès is in this connection of primary importance. A man received a sword-wound, which divided the left lateral half of the spinal cord, producing paralysis, with preservation of sensibility of the parts below. After the lapse of twelve days, considerable swelling of the whole extremity was observed, and shortly afterwards hydrarthrosis of the knee-joint. In two days this was followed by sloughing bed-sores over the right buttock and right half of the sacrum.[2] Weir Mitchell relates the case of a soldier who was, at Gettysburg, wounded over the outer part of the right clavicle, the ball passing out over the scapula; the paralyzed condition of the arm showed that the brachial plexus was involved. The joints of the fingers and wrists afterwards became slightly swollen and excessively tender to movement, but ultimately recovered under the use of the induced current.[3]

These cases show that, in consequence of paralysis from disease or injury of the nervous centres or trunks, joints lying in the course of supply may become the seat of certain forms of disease, concerning the nature of which we have no very clear anatomical data, but which clinically may be described as belonging to two categories: The one is inflammatory, leading to considerable effusion into the synovial sac, and generally yielding after a certain time; the other, also inflammatory, is accompanied by less effusion, but tends to the production of anchylosis. Either form of disease may follow any sort of lesion —gunshot, incised, or punctured wound—of the cord or of nervous trunks; or, indeed, such bruising as may be produced by dislocation or by efforts at reduction;[4] or again by disease of, or pressure on the cord, as by angular spinal curvature.[5] At first the paralysis, especially if rapidly produced, is accompanied by cutaneous thickening, œdema, and other signs of impaired nutrition, which may mark any deeper disorder; then, after a few days, the joint-malady, being more persistent, becomes apparent. Indeed, it is probable that the joint-disease does not commence till the tenth or twelfth day; it is then found either to affect several small joints, as those of the fingers or toes, or, if it attack a large articulation, to be usually limited to that one. The swelling is sometimes trifling, sometimes, especially if a large joint be affected, considerable (effusion); the skin is somewhat reddened and perspires freely. Generally, flexion rapidly supervenes, but I have known considerable over-extension to occur in the fingers. Extreme tenderness both to touch and movement is usual. This condition is very obstinate, and may outlast by weeks all other symptoms of the injury. If, for instance, this have been a bruising or wounding of nervous trunks, even after all evidence of inflammation has subsided, the joints may remain stiffened and painful on movement, and indeed, may not recover their whole range of mobility until after several years. The second form of disease, above referred to, not only affects the joints differently, but, apparently, rather the deeper structures. It commences later in the course of the paralyzing disease or injury, with less swelling, which is of a firmer and harder description, and with considerable pain, even while the parts are at rest, but greatly aggravated on the slightest movement. There is great tendency to contraction, and in these cases it appears almost impossible to prevent anchylosis. Mechanical appliances and passive motion are not only unbearable, but appear rather to increase than diminish this tendency, and in the large majority of instances the surgeon has no choice but to retain the limb in such a posture as may be most convenient for the stiffened joint. This obstinate tendency often continues, even though the paralysis may get well.

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[1] Lancet, 1846, p. 278.

[2] Journal de Physiol., t. iii. p. 47.

[3] Injuries of Nerves, p. 169. Philadelphia, 1872.

[4] Weir Mitchell, op. cit.

[5] I am not aware that any joint-disease has been observed in connection with slow pressure on nervous trunks, such as occurs in cases of tumor or aneurism.

I cannot but look on these arthropathies as simply the result of disturbances of nutrition and secretion, the vaso-motor or sympathetic portions of the supplying nerves being at the first powerfully involved, and their affections being more persistent than those of the other nerves. This view is borne out by the frequency of ulceration and sloughing in these cases, especially at spots upon which pressure may fall, as in M. Viguès's case above quoted. Hyperæmia, in some cases at first active, but soon becoming or being from the first passive, produces excess of synovial secretion followed by deficiency and thickening. If the nervous malady still persist, destruction of cartilage, and even of bone, may follow, just as œdema, ulceration, and sloughing may occur in the ordinary connective tissues.

But if the arthropathies of hemiplegia and paraplegia exhibit no, or but slight, special characteristics, the joint-affections of another nerve disease are very differently circumstanced; especially is tabes dorsalis or locomotor ataxia distinguished by occasionally producing very remarkable and peculiar conditions of the joints. The profession is indebted to Professor Charcot[1] for calling attention to and giving excellent descriptions of these affections. The papers of Ball,[2] Richet, Bourneville, and others, are also of great value. We cannot but believe, from a careful examination of the records, that the joint-malady is a more frequent accompaniment of locomotor ataxia, as it appears in France, than in either England, Germany, or America. Nevertheless, the excellent work of Dr. Buzzard[3] and the contributions of Clifford Allbutt,[4] in England, of Ponfick, Hitzig, and Westphal,[5] in Germany, and of Weir Mitchell, in America,[6] show that these conditions exist, and that more instructed attention may lead, in these countries, to the recognition of a greater number of cases than have hitherto been recorded.

The joint-trouble begins generally towards the end of the first period of the disease; that is, when the "lightning pains" have lasted some time; and either before or very shortly after incoördination shows itself. Occasionally, the arthropathy is still earlier, and may be, as in the second case of Charcot,[7] contemporary with the first attack of the characteristic pains. One of these periods of manifestation is certainly the invariable or almost invariable rule in the lower extremities, but it may be much later in the upper, because the malady is generally a long time advancing upwards from the inferior parts of the cord.

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[1] Lectures on the Diseases of the Nervous System. New Sydenham Society's translation. London, 1877–1881.

[2] Gazette des Hôpitaux, 1868–9.

[3] Pathological Transactions, vol. xxxi. p. 193, and Clinical Lectures on Diseases of the Nervous System.

[4] St. George's Hospital Reports, 1869.

[5] Berliner klinische Wochenschrift, Nos. 46, 47, 53, 1872; No. 29, 1881.

[6] American Journal of the Medical Sciences, July, 1873.

[7] Op. cit., vol. ii. lect. iv.

The patient, at the particular period of his disease which has been mentioned, discovers one day that a limb is greatly swollen; the swelling gives no pain, and is unaccompanied by fever; examination reveals the presence of much fluid in the joint as well as in the surrounding parts, and a crackling sound is emitted on movement. In a few weeks all these symptoms may disappear, leaving the limb in the same state as before, save the crackling.

In other cases the attack comes on as above without prodroma of any sort, except, in some cases, a slight amount of crackling. The swelling may run the same course, and may disappear in the same manner; but the joint is no longer normal. It may be simply deformed; it may permit manifold and irregular movements; its ligaments and capsule may be much relaxed; the joint-surfaces may be greatly altered; or with, and, indeed, in consequence of, these changes, the limb may be dislocated. Again, and this is a most important factor in our appreciation of the disease, in certain cases the bones become exceedingly fragile and break with extreme readiness, the fractures readily uniting, but with exuberant and badly-formed callus. The diseased parts are remarkably free from pain, and, indeed, patients use their limbs, and even walk, in spite of the extreme changes now to be detailed.

MORBID ANATOMY.—On examination, the bursæ around the joint are found large and relaxed, having evidently been greatly distended by fluid which had afterwards been absorbed. In one case[1] the periarticular tissues are described as of a blackish color (noirâtre); they are occasionally, in part, converted into bone or cartilage. The ligaments and capsule are distended and relaxed. The synovial membrane, thickened, grayish, and without dendritic fringes, contains sometimes a thick, citron-colored, sometimes a puruloid, synovia. In some cases false bodies, varying from the size of a pea to that of a pigeon's egg, lie in the articulation.[2] The cartilages over the whole or the greater part of the surface have disappeared, and the bone itself presents the appearance of being worn away. It is, in some cases, rather rough and furrowed; in other cases, or at other parts in the same case, it is polished though not eburnated. Around the joint are frequently osteophytes, and sometimes outgrowths from the margins of the articular surfaces. A case reported by Dr. Buzzard, showed a very singular condition which appeared like the ossification of a tendon; no opportunity for anatomical examination has as yet occurred, but the result of Dr. Buzzard's careful clinical study may here be quoted:—

"W. is a man aged 30; if we let him lie upon his back, and measure the distance from the anterior superior spine of the ilium to the tip of the internal malleolus, the tape shows a length of 33½ inches on the right side, whilst it indicates 35½ inches on the left. When the right foot is grasped, a moderate amount of traction easily reduces this disparity to one inch. On the other hand, when he stands with his bare feet on the floor, the difference in length is increased to three inches. As he lies, there is no marked inversion or eversion of the right foot, which tends, when it is absolutely left to itself, to roll slightly outwards; but he can easily control this movement, and even invert his foot with the greatest ease. He can extend his right lower extremity perfectly well, but flexion of it upon the trunk is limited; other movements are easily performed. The upper and inner surface of the right thigh—Scarpa's triangle—is distinctly rounded and prominent as compared with the corresponding part in the left limb, which presents the normal hollow. Turning to the hip, the patient being still recumbent, we find that the great trochanter is as nearly as possible on a level horizontally with the ilium, being evidently carried upwards by muscular action. The neighborhood of the hip is bulged and deformed by what examination with the hand ascertains to be a large collection of fluid in or about the hip-joint. If we lay hold of the man's thigh near the knee, we can easily, with the advantage of the leverage thus obtained, move the bone into all sorts of positions, forcing it upwards or downwards, and rotating it in and out. These movements, indeed, are very much more easily carried out, and to a greater extent, than in health. But do what we will, the other hand placed upon the swelling can discover no trace of any neck or head to the femur. The bone evidently terminates above with the great trochanter. In some of the movements, especially in rotation outwards, we are conscious of crepitus, which is sometimes much more marked than at others. The patient says that he often himself feels this crepitus in the movements of walking. Turning back now to the front of the thigh, and examining the structures below Poupart's ligament, we come upon something which is very singular. We feel a sort of narrow, bony splint, not wider than one's little finger, which stretches obliquely downwards, and somewhat inwards, for about nine inches. Above, it is pretty firmly fastened (not, however, apparently by bone) to the anterior inferior spine of the ilium, but lower down it can be easily grasped, lifted from subjacent textures, and slid loosely to and fro. When the patient extends his leg, this process of bone is held tightly, so that it is evidently connected in some way with the quadriceps femoris muscle. It appears, in fact, to occupy the position of the superior tendon of the rectus. Besides all this, we note that both lower extremities are somewhat wasted, the right especially."[1]

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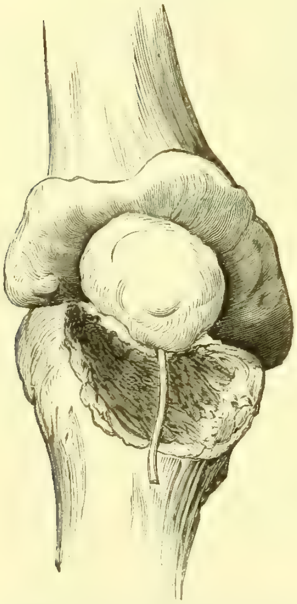
[1] Ball, Gaz. des Hôpitaux, 1868, p. 507.

[2] Westphal, Berlin klinische Wochenschrift, 1881, S. 415.

If at some future period an anatomical investigation shall corroborate Dr. Buzzard's view as to this growth of bone, it will be, as far as I know, the only instance of ossification of muscle which has been observed in this very curious disease.

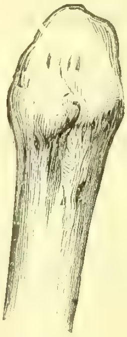
The anatomical changes just noticed show only a distant resemblance to those of arthritis deformans; the predominance of wearing away, the comparatively slight production of osteophytes, and the tendency to complete luxation, mark a very real difference. If the knee here represented (Fig. 673) be compared with a like articulation affected with arthritis deformans, there can be no confusing the two diseases, even though some amount of marginal hyperplasia is to be traced about the femoral surface. In no other joint-disease can there be found such complete wearing away, as is shown by the upper extremity of the humerus here represented (Fig. 674).

Fig. 673.



Bones of knee-joint; tibia worn away by patella; hyperplasia of articular margin. (After Schreiber.)

Fig. 674.



Upper end of humerus worn away. (After Charcot.)

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[1] Op. cit., p. 225.

The joint-malady then in its commencement (its benignant form) depends on a change in the nutritive condition—probably a profound disturbance in the functions of the vaso-motor nerves, which permits distension of vessels, arterioles, and venules, with great passive hyperæmia—whence painless but very considerable œdematous swelling, not merely of the joint, but of the whole limb. The condition is, in this benignant form, transitory, for the spinal disease itself is not progressive in a regular and uniform manner; the nerves supplying the vessels may regain their influence; the local disorder may gradually disappear.

The malignant form commences in the same manner, but the nervous defect, and therefore the local troubles, are persistent; the disorders of nutrition continue, resulting, as we have seen, in such a condition of the bones that they break with the greatest ease, or become worn away wherever subjected to friction, as in the knee under the patella, or at the joint-ends, as in the humerus above depicted. When the heads of bones have thus become worn down, and when the edges of cavities have disappeared, luxation is very readily produced, especially when the ligaments and capsules also have become lax and softened by previous distension. Although, therefore, it is at the joints that the malady has chiefly been observed, this, probably, is merely because of their mechanical value in the functions of movement, and because of the mechanical effect of such motion. The diseased condition is not confined to the articulations, but extends to the whole mass of the bone—indeed to the whole limb supplied by that portion of the spinal cord which is in a certain state and stage of disease.

At present, the peculiar central disease which produces arthropathies, has not been differentiated from the general changes of tabes. Many years ago Charcot believed that certain changes in the large cells of the anterior cornua might be the primary cause of these arthropathies, but changes very similar or identical with those which he indicated, have been found in ataxic patients without joint-affections. In one case of articular disease occurring very early, Westphal found the posterior columns degenerated (gray), but in most autopsies no central lesions which in our present state of knowledge we can directly connect with the joint-disease, have been discovered. The assumption that there may be "in the medulla oblongata a centre directly concerned in the nutrition of the osseous skeleton,"[1] is as yet hardly within the range of scientific physiology. We must be content to leave the deeper pathology of all arthropathies originating in nervous disease or injury, till a larger number of facts shall yield a clearer clue to their interpretation.

SYMPTOMS.—The joints are liable to affection in this order of frequency: (1) knee, (2) shoulder, (3) elbow and hip equally. Small joints are rarely affected. The attack, always sudden, is ushered in by no prodromata save that, in some cases, a crackling in the joint, in some a severe bout of "lightning pains," in others a quick pain like a strong electric shock, causing a fall, have preceded the joint-attack. Prof. Ball and Dr. Buzzard connect acute visceral disturbances with the arthropathy, Ball having found that a quarter of the joint-troubled patients with tabes, 4 in 16, were also affected with *crises gastriques*,[2] while Buzzard found 8 out of 21 who were thus affected. The proportion, even according to Buzzard's figures, is too small to establish any close relationship, especially as Westphal[3] says that he has seen many patients without arthropathy suffer from similar visceral affections.

Some morning, generally at the end of the first period of ataxia, the patient awakes with a limb greatly swollen, the enlargement being most marked on a level with the joint, where also it is most clearly œdematous or fluctuating; the neighboring parts are more brawny, and only pit on prolonged pressure with the finger.

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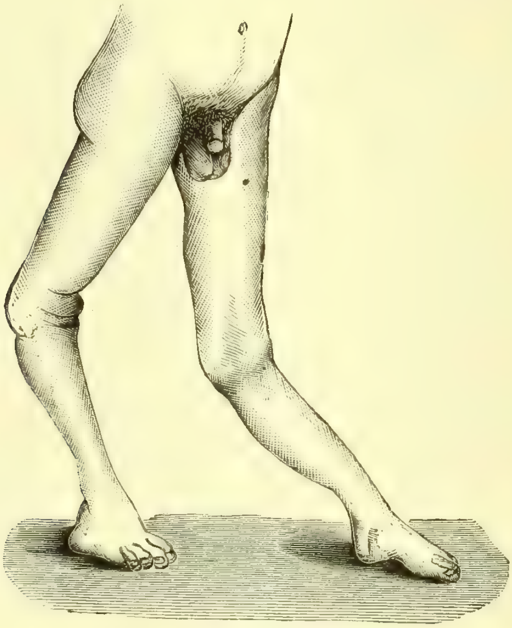
[1] Buzzard, Pathological Transactions, vol. xxxi. p. 268.

[2] Gaz. des Hôpitaux.

[3] Loc. cit.

The tumefaction, although some exceptions to this rule occur, is absolutely without pain, redness, or other inflammatory symptom; neither is there any pyrexia.[1] This condition is only transient; when it disappears it may leave the joint normal or nearly so (benign form). Or, on the contrary, when the swelling permits examination of the joint, very considerable changes may have already supervened; and these may go on rapidly to produce the most singular distortions, dislocations, or both, becoming manifest a few days after the first onset, as in the knees represented in Fig. 675, taken from Westphal.

Fig. 675.



Tabetic Arthropathy. (After Westphal.)

Besides dislocation, spontaneous fractures occur from the slightest force, such as turning in bed, or simply while walking along the ward. A singular characteristic is the almost complete immunity from pain, both at the dislocated joints and in the fractured bones. A patient described by Charcot, after an arthropathy had caused hip dislocation, used to walk some distance to her employment as a bed-maker. After a time the other hip was luxated; her legs were very movable but ill-controlled, and the joints flexible. So utterly painless were her limbs, that she used to amuse herself and the neighboring patients by floundering them about in bed. During one of these performances, the left femur was broken; some time after, while changing her position in bed, both bones of the left forearm were fractured; fifteen months afterwards the same accident occurred to the right forearm; and in the following month the left shoulder was dislocated by some very trivial movement. The fractures

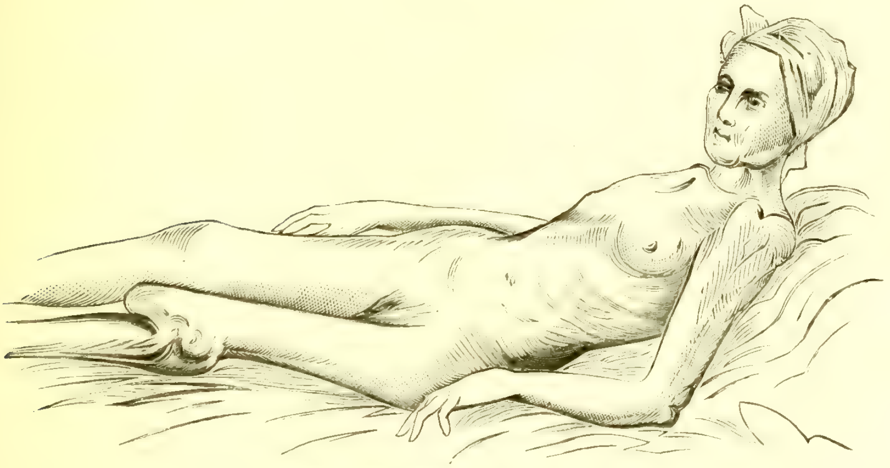
[1] The usual quick pulse of ataxia must not be mistaken for that of fever.

became united, apparently without difficulty, but in a most clumsy manner, the left radius and ulna being luted together by ill-formed callus. The left femur was so shortened that it was found, after death, to measure only 19 centimetres (7½ inches), while the right measured 50 centimetres (19½ inches).[1] The patient died, about a year or sixteen months after admission to the Hôtel Dieu, of ruptured aortic aneurism. In other cases, the bone after fracture has become very thin and twisted.[2]

The absence of pain in both dislocations and fractures is very important in a diagnostic point of view, as is also the peculiarly loose, mobile condition of the displaced bone—quite unlike any other luxation; for instance, in one of Dr. Buzzard's patients, it is said that "on removing the leather casing from the right knee, the joint seemed to fall abroad." The patient herself could replace the bones, and said that when she put on the casing she had to take the bones, put them straight in their places, and tie them together with a bandage, to keep them together while she put on the splint. The joint could be twisted about and the bones knocked together audibly without causing pain. Manipulation gave a feeling as of disappearance of all ligamentous connections, the bones seeming only held together by muscular and cutaneous tissues.[3]

Such a condition may well be believed to have existed in the knee and shoulder of a patient (represented in Fig. 676), who, for many years, was in the Salpêtrière, one of M. Charcot's favorite examples of this disease.

Fig. 676.



Tabetic arthropathy. (After Charcot.)

All the conditions of this disease, viz., presence of lightning pains, sudden advent, painlessness, extreme mobility, and absence of nodosities, mark it so distinctly from arthritis deformans, that it hardly appears desirable to contrast special points for differential diagnosis.

Treatment.—All that the surgeon can do for a disease depending, as this does, on a deep central lesion, is to retard the wearing away of bony surfaces by the friction of one part on another, and to obviate as far as possible dislocation and fracture. Both these objects can only be furthered by rest, more or less complete.[1] Light splints, bandaged on the limb, may be used for this purpose. The initial tumefaction may also be combated by judicious bandaging, but only lightly applied, lest more severe pressure should augment the tendency to bony absorption. Ball recommends a succession of blisters, but he gives no example of their benefit, and it is not easy to perceive what could be hoped from their application.

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[1] This shortening appeared to be due to the friction of the two fragments causing atrophy of the upper one.

[2] Talamon, Revue Mensuelle de Médecine, 1878.

[3] Path. Trans. vol. xxxi. p. 201.

When dislocation has occurred, a case of leather, adapted to the deformed limb, should be applied. When fracture takes place, it must be treated on ordinary principles, the tendency to deformity being specially borne in mind. The whole local management must be subordinated to the condition and treatment of the neuropathy.

TUMORS OF JOINTS.

Tumors of joints are neoplasms originating in or upon the articular ends of bones.[2] The common connective tissues surrounding the joints may, like those tissues in other parts, be the site of tumors, but in point of fact they rarely are so affected; and any neoplasm so placed has no especial relation to the joint as a mechanism or organ. The tumors with which we have to do here are: (1) exostosis; (2) chondroma; (3) sarcoma; (4) carcinoma; (5) angeioma; (6) aneurism of bone; and (7) echinococcus of bone. The three last are excessively rare.

Fibroid tumors, which are common enough about the bones inclosing the mouth and nares, where they are commonly called nasopharyngeal polypi, are very rare in the neighborhood of joints; while cystic tumors proper, infest almost exclusively the jaw-bones.

EXOSTOSIS is to be distinguished from hyperostosis, in that the former has a distinct and well-defined stalk from which the bulk of the tumor grows, but which itself does not increase. Hyperostosis has no defined or limited stalk, but is rather a conical, slightly elevated outgrowth from a broad, indefinite basis; its increase takes place, not by augmentation of the elevation, but of the base; it is, indeed, a local hypertrophy rather than a tumor, and resembles the thickening which results from chronic osteitis.

Exostoses are more especially accustomed to grow from the immediate neighborhood of epiphyseal junctions, and are therefore more common in youthful than in later life. Their favorite seats are: (1) The lower end of the femur; (2) the upper end of the tibia; (3) the upper end of the humerus, particularly from either edge of the bicipital groove. The exostoses that thus grow from limb-bones all belong to the cancellous variety—that is to say, their interior consists of cancellous or spongy bone, coated by an outer layer of more compact, but still soft, osseous tissue; and this is often covered by a layer of cartilage, which probably is the element of increase, ossifying on the attached, and growing on the free surface. Any portion of that surface which produces friction on superjacent structures, is very commonly covered by a bursa. In shape, exostoses assume two varieties; they are either smaller at their tip than at their base, and curved so as somewhat to resemble the spur of a cock—these are chiefly such as grow from or near to the attachment of a tendon—or they are mushroom-shaped, having a small cylindrical stalk, and a broad, outspreading end. These are such as in their growth project against the skin or tight fasciæ, or otherwise against firm obstacles.[1] Indeed, the shape of these growths depends chiefly or entirely on the pressure of surrounding parts. They are often multiple, several appearing on different bones, or on the same bone, and the tendency to these multiple exostoses is certainly hereditary. In 1879 my friend, Mr. Whitehead, now of the Army Medical Department, brought me a boy on whom we counted 238 exostoses scattered over every bone which could be felt. The boy's father, now no longer alive, had had, according to the lad's account, a great number of similar growths; and Mr. Whitehead took some pains to obtain an opportunity of examining the boy's brother, and told me that he had even more exostoses than the lad whom I saw.

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[1] See Weir Mitchell, The Influence of Rest in Locomotor Ataxy. American Journal of the Medical Sciences, 1873.

[2] False bodies within joints are not to be considered as tumors of joints.

One form of bunion consists of a mushroom-shaped exostosis, springing from the inner part of the first metatarsal bone, close to the phalangeal joint. It is doubtless produced in the first instance by wearing pointed shoes, forcing the great toe outwards, and causing excessive pressure to fall on the head of the metatarsal bone. Between the exostosis and the skin a bursa is developed, which frequently inflames, and sometimes suppurates. Exostoses are easily distinguished from all other growths by their form and situation; by their attachment to or union with the bone, following therefore its movements and being immovable independently; by their presence being unobserved until a certain size has been attained; and then by their slow growth.

These tumors very rarely produce trouble in the joint itself, but they frequently embarrass movement by pressing upon tendons and fasciæ, and thus interfering with their action.

Treatment.—No internal remedy, nor any outward application, affects the growth of an exostosis, and therefore the only remedy is detachment. Such an operation, however, could not be thought of for a moment in the case of multiple tumors; nor, indeed, does it appear to me desirable in single growths, unless pain on movement or very considerable deformity be produced. The removal is, as a rule, very easy.[2] A simple, longitudinal incision upon the most projecting point, or, if the growth be large, a semilunar cut, permitting a flap to be turned up, serves to expose the growth, whose base is then to be cleared with the scalpel or raspatory; a narrow saw, an osteotomy chisel, or cutting bone-forceps, may then be used to sever the base of the growth from its attachment. The section should be made so that no part of the stem is left attached, but the bone surface must be made level and smooth. If this have not been effected by the cutting instrument, the osteotrite or gouge must be used to make the part smooth and even. Great circumspection should be exercised in recommending this operation for the exostoses of bunions, especially in persons advanced in life.

The late Mr. Maunder, observing that in certain cases accidental fracture of an exostosis had relieved the patient from all pain and trouble, imitated this fortuitous occurence in two cases.[3] Protecting the skin by chamois leather, he seized the tumor in gas-fitters' pliers, and broke its stalk, afterwards using passive movement to prevent reattachment. In one case this attempt was unsuccessful (exostosis above outer femoral condyle), but the tumor became reunited in a position which hardly at all incommoded the patient. In the second case (exostosis on inner tuberosity of tibia) the growth remained loose.

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[1] Exostoses which spring from the subscapular fossa and grow forward, are always thus flattened against the thorax.

[2] We have not now to do with ivory exostoses.

[3] Clinical Society's Transactions, vol. xi. p. 59.

The method is worthy of consideration whenever the presence of a moderately thin stem is suspected.

Chondroma.—Closely allied to, perhaps an incomplete form of, the above, are the *ecchondromata* that occasionally occur in youthful patients, about the edges of epiphyseal junctions; they are rare and unimportant, seldom attaining, unless by ossification they become exostoses, any inconvenient size. At page 340, a certain form of loose body in the joint is described as an ecchondrosis growing from articular cartilage. More important are *enchondromata.* All cartilaginous tumors grow by preference from bones, yet occasionally they have been found in soft parts, as the mamma, or testicle. Enchondroma of bone may be in its origin either peripheral or central; the former variety is the more rare, and commences later in life, but sometimes it is not possible, even by anatomical examination, to distinguish between a peripheral tumor growing into the medullary canal and a central enchondroma growing outward. Clinically, they are absolutely indistinguishable; but the former is generally single, the latter multiple. A peripheral enchondroma commences in the fibrous layer of the periosteum, or in the more superficial layers of the bone; it both increases outwards, and, probably by pressure, invades likewise the osseous structure, penetrating into the medullary canal or cancellous structure. Central enchondroma commences in the medullary cavity, or cancellar portion, and after invading a certain district of those parts, causes absorption of the bone walls, and presents itself outwardly. Either form then appears as an irregularly round or ovoid tumor, nodular on its surface; sometimes remarkably so. It is sessile on the bone, but not so immovably as an exostosis, the elasticity of cartilage giving a sort of springy mobility, very different from the feel of a bony tumor; this quality also imparts to the lump, when pretty strongly compressed, a resiliency which the quite unyielding resistance of bone does not afford. When the tumor approaches the surface, and the skin is stretched tight over it, a slight translucency may aid the diagnosis. The favorite seats of enchondromata also assist their recognition; thus half the cases occur on the bones of the hand and foot, but five times as often on the former as on the latter; in either situation the tumors are multiple. The next seat of predilection is the tibia; nearly equal are the femur and humerus; the lower jaw and the pelvis stand next.

Although, as actual tumors, these growths may not make their appearance till at a later age, they probably begin at a very early period of life, their growth being slow. Every museum possesses at least one specimen of a hand crippled and deformed by a number of enchondromata growing from the phalanges or metacarpus, sometimes also from the ulna or radius. Enchondromata affect the joints by their proximity, but do not involve them in disease. Even in these cases of multiple growth, the joints, though the bulk of the neighboring tumors may affect their mobility, are left unaltered.

This neoplasm is often mixed with myxoma, sarcoma, or carcinoma; many also, which appear unmixed, are prone to mucoid and cystic degeneration; either circumstance gives greater gravity to the prognosis. Pure, undegenerated enchondroma is, as a very general rule, benignant, though instances of systemic infection have occurred. Recurrence *in loco* changes this characteristic, for such a condition is very apt to be followed by general infection.[1]

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[1] Recurrence must be carefully distinguished from mere continuance of growth in a part of the tumor not removed. The histology, diagnosis, and prognosis of tumors are treated in a part of this Enclyclopædia especially devoted to the subject; here we have to do with them merely as they affect the joints. I have not included among tumors of joints the various false bodies described at page 339.

Those enchondromata which spring from the pelvis and scapula are, above all others, prone to recurrence and general dissemination.

Osteoid chondromata[1] are formed of tissue analogous to fibro-cartilage, not, as those just mentioned, of a hyaline variety. They have a special predilection for the ends of long bones, chiefly for the lower end of the femur or upper end of the tibia. From their seat of origin they encroach more and more on the shaft of the bone, while the older parts, growing likewise in circumference, are larger than the newer portions; they occupy not one side only, but the whole circumference of the bone. Thus, instead of forming, like simple enchondroma, a more or less round, nodulated lump, projecting on one aspect of the bone, they seem like a conical enlargement of the whole part, the thick end of the cone being always towards the joint, whose cartilage, however, remains intact; they are less hard than enchondromata, and are smooth on the surface.

At first, and while still small, they appear like mere hypertrophies of the bone itself; but they grow rather rapidly, and then become less hard than bone-substance, being at first within the periosteum, which forms their capsule or wall. Afterwards, that tissue is either absorbed and ruptured, after which the rate of growth increases, and the tumor, if left alone, goes on increasing as long as the patient lives, sometimes attaining an enormous size.[2] Very occasionally the tumor remains sufficiently soft to be cut with the knife, but it more usually ossifies pretty quickly. Sections of the softer parts have a fibrous appearance, but cartilage-cells, sometimes arranged in rows, may be detected with the microscope. Vessels permeate the structure, and the ossification is in needles and plates, so that, when the soft parts are removed by maceration, the bony parts left behind are somewhat similar to the architecture of a wasp's nest. The shell and tracing of the original bone may, as a rule, be found passing through the mass.

The *prognosis* of chondroma is not always favorable. The only *treatment*, amputation, should be performed above the bone from which the growth springs, and so that no part near the tumor forms the flap. Thus, exarticulation at the hip is necessary if the growth spring from the lower end of the femur; or in the lower third of the thigh if it arise from the tibia. Even under these circumstances, secondary growths sometimes occur in the lungs or liver.

SARCOMA AND CARCINOMA.—Sarcoma of bone has its favorite seat on the jaw. One form of epulis is well known as a giant-celled, or, as it is sometimes called, a myeloid sarcoma, a term which must not be taken as coincident with Paget's myeloid tumor.[3] It had better be confessed at once that our knowledge of many sarcomatous tumors is as yet in a very unsatisfactory state, especially in regard to the malignancy or benignancy of different forms of growth. Nor does it at present appear that their anatomical characteristics correspond in any close manner with their clinical course. Indeed, one of the chief authorities on the histology of tumors reverts to naked-eye appearances:—

> "We must mention one more peculiarity of sarcomata, namely, that they are sometimes so white, and at the same time so soft, as to have the greatest resemblance to brain-substance. These medullary (encephaloid) sarcomata possess the malignant qualities of sarcomata in the very highest degree; they may still have any of the histological structures previously referred to."[4]

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[1] Virchow, Die krankhafte Geschwulste, Bd. i. S. 597.

[2] Volkmann refers to a preparation in the museum at Halle, in which the tumor was almost a yard in *diameter* (fast eine Elle im Durchmesser). Pitha u. Billroth, Chirurgie, Bd. ii. Abth. 11, S. 461.

[3] Lectures on Surgical Pathology, p. 544.

[4] Billroth, Lectures on Surgery, Sydenham Society's Translation, vol. ii. p. 415.

As Prof. Billroth nowhere mentions cancer of bone, save to deny the existence of primary epithelioma of that structure, it would seem that he regards all malignant growths of bone as sarcomata; but a great number of excellent authorities—Virchow, Foerster, Volkmann, Paget, and others—speak of encephaloid cancer as springing from, or originating in, bone. My own observation leads me to the conclusion that many of these tumors are certainly carcinomatous, though most of those which are distinctly encapsuled must be regarded as sarcomata.

The ends of the long bones, and more especially the head of the tibia, the condyles of the femur, and the upper extremity of the humerus, are not very unfrequently the seat of sarcomata. They occasionally follow injury, after the method to which I last year gave the name of "acute traumatic malignancy,"[1] but more often appear to arise spontaneously, although even here the possibility of some apparently unimportant and probably forgotten injury must not be overlooked. They are affections of early life, rarely occurring after thirty years of age, and being most frequent between the fourteenth and the twentieth year, and occasionally arising even in infancy.[2] They mostly spring from the periosteum, but occasionally from the cancellous structure of the bone. Their microscopic characters, as in the above quotation Billroth has stated, may have any of the sarcomatous characteristics, but the most frequent varieties are the giant-celled, the round-celled, and the oat-celled (spindle-celled). The capsule which surrounds the structure is very thin in most parts, and in spots imperfect, probably having been absorbed or ruptured by the pressure of the rapidly growing mass.

The clinical appearances and symptoms of these growths are, when they have reached a considerable size, easy of recognition; but unfortunately, while they are still quite small, when diagnosis would be very important, it is also very difficult. The periosteal sarcoma begins, either after or without some traumatism, as a very slightly painful enlargement, and there will be a certain difficulty and restraint of movement, according to the situation, rather than the nature of the tumor. The tenderness is but slight, nor are there any inflammatory symptoms; the tumor itself is rounded or ovoid, rarely nodulated, and moves in flexion or extension with the bone, though if situated on a bone that can be rotated, it moves to a much slighter extent; it is, unless quite at first, soft and doughy. The patient's health as a rule is good, nor are any evidences of cachexia to be observed. These appearances, although obscure, should always arouse suspicion. An almost painless, non-inflammatory, ovoid tumor, sessile, but not rigidly so in the neighborhood of an epiphyseal junction, is of no good augury; no such growth should be allowed to remain unwatched.

The sarcoma which springs from the interior of a bone, often before any swelling is perceptible, gives rise to a dull, aching pain, analogous to and often mistaken for rheumatism; then some enlargement of the bone itself appears, and, in its turn, may be mistaken for ordinary osteitis, or for central abscess. After a little while, a great portion of the osseous walls being absorbed, only a thin shell is left, which very frequently crackles. Afterwards a certain portion of this bony cortex gives way, so that it may be traced on the side of the tumor, but the apex presents mere soft tissue. At this time it is impossible to distinguish between medullary sarcoma and soft cancer. These central, soft tumors of bone, when they have thus emerged outwards, very often pulsate, even though the growth itself may not be very vascular. The pulsation appears to depend on the increased size of the vessels which nourish the tumor; these, being confined in a non-yielding case, gain room for their pulse-throb by slightly extruding, at each beat, the tumor itself.[1] No periosteal sarcoma, as far as my experience goes, ever gives rise to pulsation. Thus the central may be distinguished from the periosteal sarcoma, by the presence of a shell of bone around the base of the growth, and usually by pulsation.

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[1] British Medical Journal, February 11, 1882, p. 187.

[2] I amputated an arm at the shoulder-joint of a boy aged eleven, and I have twice seen malignant growth at the knee in young children; before the end of the first year in one, and at two years and three months in the other case.

While still small, the diagnosis of sarcoma is doubtful, but the rapidity of its growth, and the development of certain appearances thereby produced, soon render its recognition easy. The tumor by this time is pyriform, with its larger end towards the joint, and usually with an even surface;[2] the skin over it is remarkably white and colorless, though late in the disease a blush is frequently perceived at those parts where the increase is greatest, and where the tumor presses on the skin. Over the white surface is spread a network of veins in close meshes, the blue coloring of the blood seen through the white skin giving a very striking and characteristic appearance. These tumors, though they run up to and even involve the neighborhood of the joint, so that its'contour is concealed, do not implicate the joint itself, the cartilages on both bones remaining perfectly healthy. Thus the movements of the articulation are smooth, and only restricted by the contour of the growth coming in contact with parts of the adjoining limb-segment or of the trunk. The tumor feels soft, doughy, and hardly elastic; it moves in flexion and extension, and also follows the bone in rotation, but not to the full extent, especially if the tumor be periosteal; for the tissues of the neoplasm yield somewhat, so that the outer parts move less than those close to the bone.

Most sarcomata springing from the joint-ends of bones are malignant;[3] they may be distinguished by their rapid growth, pyriform shape, and large surface-veins, from the few—very few—soft, non-malignant growths. Although sarcomata and carcinomata growing from the shafts of long bones not unfrequently undergo ossification (osteo-sarcoma and osteo-cancer), that change is rare in such as grow from the articular ends. Sundry other degenerations, however, take place, such as the cystoid, forming a sort of tumor that has been called myelo-cystic. If such a tumor have previously been very vascular, hemorrhage into one of these cysts may occur, and, the rent in the vessel remaining unsealed, an appearance which has probably been more than once taken for aneurism of bone, is produced. Or cystic, fatty, or mucous degeneration may, in great part, destroy the original structure of a very vascular sarcoma, leaving behind a plexus of enlarged vessels, and giving a deceptive appearance of aneurism by anastomosis of bone.

Other forms of cancer very rarely occur primarily in the long bones near joints; epithelioma probably always originates in the soft parts, and is propagated secondarily to the neighboring superficial bone. Both scirrhus and colloid cancer of bone are mere pathological curiosities;[4] when they do occur, they are apt to affect many bones and to assume the diffuse form.

ANGEIOMATA OF BONE are excessively rare. The frontal, parietal, and occipital bones do indeed participate secondarily in cirsoid aneurisms of the scalp which have persisted for years and attained certain dimensions, but this is a mere extension of disease along the course of affected vessels, a very different thing from primary angeioma of bone.

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[1] The differential diagnosis between this disease and aneurism of bone will be given immediately.

[2] The surface in carcinoma is sometimes nodulated.

[3] The central sarcomata of the jaws, more especially of the lower jaw, are rarely malignant; in my experience those of the limbs generally are so.

[4] Some observers have spoken of colloid of the bones; but it is to be noted that with increased knowledge of the minute anatomy of tumors, such cases have become rarer, and in some instances a plentiful admixture of sarcomatous elements leaves room for doubting whether the growth is not in reality a mucoid degeneration of sarcoma.

ANEURISM OF BONE, that is, sacculated enlargement of a vessel within the osseous structure, gradually making its way outward, is extremely rare, and there is no doubt but that many of the older reported cases were instances of sarcoma that had undergone cystoid degeneration, a vessel enlarged by the hyperplasia having opened into one of the cysts. Nevertheless, real aneurism of bone does occur, and is a disease very difficult to be distinguished during life from some of the pulsating tumors which have been referred to. One point of difference is that in aneurism the tumor becomes more markedly smaller when pressure is made on the vessel above, and regains its former size much more rapidly. The pulsation is more distinctly expansile, not the up and down heave of a vascular sarcoma. Generally, aneurism of bone emits a very distinct, sometimes a loud, bruit, while if there be any sound connected with a pulsating sarcoma, it is a mere continuous murmur.

The favorite sites of osteo-aneurism are the head of the tibia, the condyles of the femur, and the head of the humerus. This disease, unlike the neoplasms which we have been considering, and which, as a very general rule, leave the articular cartilages intact, rapidly destroys those structures.

Treatment.—When there are grounds for believing that a pulsating tumor of bone is aneurismal, pressure, the use of an Esmarch's bandage, deligation, or other means mentioned in the article on Aneurism,[1] may be resorted to. Even if there be doubt as to diagnosis between a new growth and an aneurism, one of those methods may be advantageously employed before resorting to the severer means, amputation, which may still remain as a last resource, should further events negative the more hopeful diagnosis. In some cases, especially if the tumor lie deep, as in the iliac fossa, a positive diagnosis appears to be impossible.

ECHINOCOCCUS OF BONE.—An exceedingly rare tumor of bone is the hydatid or echinococcus, which, when it does occur, usually occupies either the bones of the skull or those of the vertebral column; but a few cases are on record of such parasites infesting the ends of long bones, and making their way into the neighboring joints, which by proliferation they have filled. The remarkably indolent tumor thus produced bears the strongest resemblance to true hyperostosis; indeed, the hydatid lying in the bone cannot be distinguished; the surgeon can only perceive the hypertrophy of bone which it sets up. After a time, the osseous case inclosing the cyst becomes, in some part of its superficies, absorbed, when this soft body may be felt, extremely like a simple cyst or an abscess, bound down by a firm wall.[2] As far as I know, no case of echinococcus of bone has ever been diagnosed, until by incision the cysts have been brought to light.

Whether by injection with iodine, carbolic acid, or chloride of zinc, the parent cyst may be successfully killed—that is to say, whether hydatids of bone may be successfully treated as we treat hydatids of the liver—has not yet been clinically determined; but the surgeon's duty would certainly be to make the attempt.

In regard to diseases of the joints, the subject of tumors is especially of interest in respect to diagnosis and prognosis. The tumors which most frequently occur — the bony, cartilaginous, sarcomatous, and carcinomatous growths—rarely affect the constituents proper of an articulation, save by extension of disease, and even then only tardily; the synovial membrane and the cartilages are not involved, but since the tumors lie close to or over the joint, and interfere with its movements, they clinically, and to the patient actually, present themselves as joint-diseases. The important points for him and for the practical surgeon to consider, are the probability of increase, with destruction of the joint, and with great incumbrance; the necessity or otherwise of removal of the tumor, or of the whole limb; the likelihood of recurrence *in loco;* and above all the probability of systemic infection.

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[1] See Vol. III. p. 412.

[2] Spontaneous fracture of bone has several times followed the development of echinococcus in its shaft.

EXCISIONS AND RESECTIONS.

BY

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THE term EXCISION (from the Latin *ex*, out or from, and *cædo*, I cut), or EXSECTION (*ex* and *seco*, I cut), is properly applied to such operations as have for their object the removal of an offending part, without that total ablation of the affected portion of the body which is implied by the term *amputation*.[1] Hence, we speak of excisions of tumors, of joints, of the eyeball, etc. The term RESECTION (from the Latin *reseco*, I cut again, cut loose, or shorten by cutting, cut short), is properly used in a special and restricted sense, its etymological components being taken separately and in conjunction with omitted words, to signify an operation which takes away a middle portion and brings the ends together again, and is thus in strict surgical language limited to partial excisions of the long bones. Hence, while we *excise* the astragalus or scapula, we *resect* the humerus or ribs.[2] The revival of excision as a remedy for joint-diseases, chiefly due to the teaching and example of the great modern advocate of "conservative surgery," the late Sir William Fergusson, has caused this operation to attain such importance in the practical work of surgeons, that though the term "excision" is, as has been seen, applicable to a large number of diverse procedures, yet, when the word is used by itself, it is now understood to signify an operation for the removal, partial or complete, of an injured or diseased articulation, or of a bone, and generally one of the flat or short bones, which can be removed entire without jeopardizing the usefulness of the affected part.

HISTORY OF EXCISION AND RESECTION.

The operation of excision or resection, in cases of compound fracture and dislocation, was certainly known to the ancients. Whether or not we acknowledge the authenticity of the Hippocratic treatise, "De Articulis"—and, for my own part, I see no reason to profess skepticism in the face of evidence which has convinced such thorough scholars as M. Littré and Dr. Francis Adams[3]—there can be no doubt that long before the Christian era these operations were familiar to surgeons as a matter of theoretical teaching, even if they were not often put in practice. Having just declared that in cases of compound dislocation, except of the joints of the toes or fingers, attempts to retain the protruding bone would be improper, and would certainly prove fatal through the supervention of convulsions or gangrene, Hippocrates goes on to say, that not only may protruding articular extremities of the finger-bones, and protruding broken ends of the same (without dislocation), be safely cut away, in most cases, but "complete cuttings away, also, of the bones at the joints, both in the foot, and in the hand, and in the leg (those near the ankle), and in the forearm (those by the wrist)" will in most instances be harmless, unless fainting should occur, or continued fever on the fourth day.[1] In his treatise on compound fractures (in the continuity), he is still bolder in his recommendations, and declares that it is necessary to saw or file off the projecting bone if it cannot be reduced, if it irritate or lacerate the soft parts, or interfere with sensation, or if it be itself denuded.[2]

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[1] See Vol. I. p. 551.

[2] French writers use the word *résection* for excision of the bones and joints generally, and Percy and Laurent make a distinction between *résection* of the hard and *rescision* of the soft parts. (Dictionnaire des Sciences Médicales, tome xlvii. p. 538. Paris, 1820.)

[3] The Genuine Works of Hippocrates (Preliminary Discourse), vol. i. pp. 24 *et seq.* London, Sydenham Society, 1849.

Celsus, while even more succinct than Hippocrates, would appear to make the rule more general; for, after quoting with approval the former author's cautions as to reducing compound dislocations, he adds briefly: "If the bare bone project, it will always be a hindrance; therefore what sticks out is to be cut off."[3] He directs that, in dressing compound fractures, if a little fragment of bone protrudes, it is, if blunt, to be replaced; if sharp and long, to be cut off, and if sharp and short, filed off; and if denuded, to be cut off. He considers the reduction of fractured thighs particularly difficult, and says that if the fragments of the femur yield between themselves (overlap), it is almost necessary to cut them off.[4]

Galen declares that the teaching of Hippocrates is so plain and satisfactory as to need no comment, and merely adds that "modern physicians" call dislocations in which the bone protrudes "εϰβυρσωματα," and reminds the reader that the danger of the operation recommended, like that of the injury itself, increases with the magnitude of the joint affected.[5] He throws no additional light upon the operation of resection as applied to compound fractures.[6]

Paulus Ægineta departs from the teaching of the Master in the matter of compound dislocations, which he advises should be, in every case, reduced; but approves resection in irreducible compound fractures, directing that the projecting fragments should be sawn off or cut off with an instrument which Dr. Adams speaks of as a "chisel," but which seems to me more analogous to cutting-forceps (literally, "antithetic through-cutters").[7]

The Arabian writers add nothing to our knowledge of this subject; Albucasis,[8] who is the only one who deals with the matter in detail, giving advice almost identical with that of Paulus Ægineta: "Cut it off," he says, "with one kind of the cutting instruments which we have spoken of, or saw it with one of the saws, as may be possible to you." Haller,[9] however, in his analysis of Rhazes's "Liber Continens," quotes from that author a statement that if the bone be corrupted [carious] in "spina ventosa," a cure cannot be obtained unless the bone be extracted. I have not had the opportunity to consult Rhazes's work, but from Haller's brief reference this looks very much like a recommendation of *excision for disease.*

The advice of Hippocrates, that resection should be practised in cases of

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[1] Hippocratis opera omnia, edit. cur. C. G. Kuhn, t. iii. p. 246. Lipsiæ, 1827.

Ibid., p. 121.

[3] A. C. Celsi Medicinæ lib. viii. cap. xxv. Edit. L. Targæ, p. 471. Lugd.-Bat., 1785.

[4] Ibid., pp. 452–454. This passage might also be rendered to the effect that in such a case the patient would almost necessarily perish.

[5] Claudii Galeni opera omnia, edit. cur. C. G. Kuhn, t. xviii. pars i. p. 714. Lipsiæ, 1829.

[6] Ibid., t. xviii. pars ii. p. 603.

[7] Pauli Æginetæ Medici Optimi lib. vi. cap. cvii., cxxi. Editio princeps. Venetiis, in ædibus Aldi, etc., fol. 100, 104.

[8] De Chirurgia, lib. iii. sect. xix. Edit. cur. J. Channing, Oxon., 1778, t. ii. p. 589.

[9] Bibliotheca Chirurgica, t. i. p. 130. Basileæ, 1774.

compound fracture in which the bone protruded from the soft parts, appears to have been occasionally remembered and acted upon in subsequent ages, while his similar recommendation as regarded compound dislocations, was quite forgotten. Thus Salmon,[1] speaking "of a fracture with a wound, the bone sticking out," says, "But if this Reposition cannot be easily done, or not without pain and violence, then of two evils, the lesser is indeed to be chosen; and therefore that the Reduction may be made, the end of the longer bone is to be cut off with a cutting File, or with a sharp, fine saw, or some other Instrument, that it may be made a little shorter;" but in his account of dislocations,[2] has no further suggestion, "when the Joint or Bone cannot be reduced," than that the part should be comfortably supported, and care taken "for Universals and Diet." Wiseman, too,[3] speaks of resection in compound fractures, and narrates a case in which he successfully employed the operation, but makes no reference to it in connection with the treatment of dislocations.

The first record which we have, in modern times, of an excision for *compound dislocation*, is Mr. Gooch's statement,[4] that, "many years ago," Mr. Cooper, late of Bungay, sawed off the ends of the tibia and fibula, instead of amputating, in a case of compound luxation of the ankle in an elderly man, with the happy result that the preserved limb was so useful "that the poor man walked and wrought for his bread many years after." Mr. Cooper was afterwards equally successful in a compound dislocation of the wrist, in which the radius protruded, and Mr. Gooch himself successfully employed a similar operation in the treatment of a compound dislocation of the thumb. Mr. Wainman, of Shripton, successfully excised the lower part of the humerus for compound luxation of the elbow, in 1759,[5] while on August 23, 1762, Mr. Filkin, of Norwich, performed the first recorded *excision for disease*, in a case of long standing caries of the knee.[6]

To Mr. Park himself belongs the credit of having first formally recommended excision as a substitute for amputation in cases of incurable arthritis, or, as it was commonly called, "white swelling," though he was anticipated in the actual performance of the operation by Filkin, of Norwich, as above mentioned, in the case of the knee; by Bent,[7] of New Castle, and Lentin[8] (1771), and Orred,[9] of Chester (1778), in the case of the shoulder; and by Justamond,[10] of London (1775), in the case of the elbow.[11] Park's first operation was performed on July 2, 1781, on Hector McCaghen, "a strong, robust, Scotch sailor, aged thirty-three," who was suffering from disease of the knee-joint of ten years' standing. The operation resulted so successfully that the patient "afterwards made several voyages to sea, in which he was able to go aloft with considerable agility, and to perform all the duties of a seaman," and "was twice shipwrecked, and suffered great hardships, without feeling any further complaint in that limb."[1] Mr. Park's second case (1789) terminated less favorably, the patient dying between three and four months after the operation.[2]

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[1] Ars Chirurgica, Book vi. chap. viii. (vol. ii. p. 1222). London, 1698.

[2] Ibid, Book vii. chap. iv. (p. 1303).

[3] Eight Chirurgical Treatises, sixth edition, vol. ii. pp. 258, 259. London, 1734.

[4] Cases and Practical Remarks in Surgery, etc., second edition, vol. ii. p. 323. Norwich, 1767.

[5] Park's letter to Mr. Percival Pott. Cases of the Excision of Carious Joints, by H. Park and P. F. Moreau, with Observations by James Jeffray, M.D., p. 10. Glasgow, 1806. Mr. Park's letter is dated September 18, 1782, and he says that Mr. Wainman's operation was done "twenty-three years ago."

[6] Park's letter to Dr. Simmons. Ibid. pp. 52–55.

[7] Philosophical Transactions (London), vol. lxiv. p. 353. (Hodges.)

[8] O. Heyfelder, Traité des Resections, trad. par le Dr. E. Bœckel, p. 163. Strasbourg et Paris, 1863.

[9] Philosophical Transactions (London), vol. lxix. p. 6. (Hodges.)

[10] London Medical Journal, vol. iv. p. 282; Park, op. cit., p. 55.

[11] All of the above (except Filkin's) seem to have been partial operations. C. White's case (1768), usually regarded as the first example of shoulder-joint excision, appears to have been actually a resection in the shaft of the bone, the caput humeri having been allowed to remain attached to the glenoid cavity, and the same may be said of the similar operation performed by Vigaroux, of Montpellier. See upon this point Dr. R. M. Hodges's well-known and admirable prize-essay on the Excision of Joints, Boston, 1861 (page 22).

Meanwhile, in France, the elder Moreau had independently conceived the idea of removing carious bones and joints by an operation less mutilating than amputation, and in August, 1782, had put his ideas in practice by cutting out "a caries of considerable extent, from the lower end of the leg bones of a man called Lecheppe."[3] The operation was completely successful, and in the following year (1783) M. Moreau laid his views before the Academy of Surgery,[4] definitely proposing the operation of complete excision of diseased articulations. In 1786, the same surgeon communicated to the Academy the history of a case in which he had in that year successfully removed the whole shoulder-joint for disease—the first recorded case of complete shoulder-joint excision—but neither of these communications seems to have excited enough interest to have been thought worthy of publication. A third memoir, presented in 1789, met with almost universal disapproval and condemnation, the learned members of the Academy, as the younger Moreau tells us, finding it more convenient to deny, than to examine, the facts on which it was grounded;[5] and except for the operations in military practice of the illustrious Percy, and certain isolated cases in the hands of the two Moreaus, the father's pupil, Someillier, and a few others, the practice of excising diseased joints met with so little favor in France that even Velpeau, writing in 1839, though deciding that, "upon the whole, the mass of the advantages of resection [excision]" was "more considerable than that of its inconveniences," yet averred that, as compared with amputation, the balance was so nearly even, that it might "well be permitted to hesitate before absolutely sanctioning its utility."[6]

In Great Britain, too, the operation was very slow in making its way into general surgical practice, the actual establishment of excision as a recognized procedure, when applied to the shoulder and elbow-joints, being fairly attributable to Mr. Syme, of Edinburgh, in the years 1826 and 1828 respectively; as regards the hip, knee, and wrist-joints, to Sir William Fergusson, in 1845, 1850, and 1851 respectively; and as regards the ankle-joint, to Mr. Hancock, also in 1851.

Among the earliest American advocates of this operation may be particularly mentioned Drs. Ingalls, John C. Warren, and Henry J. Bigelow, of Boston; Drs. Gurdon Buck and Lewis A. Sayre, of New York; Drs. Thomas Harris and Joseph Pancoast, of Philadelphia; Dr. R. A. Kinloch, of Charleston; and Dr. Edmund Andrews, of Chicago.

I do not intend to review here the controversies as to the propriety, particularly of hip-joint and knee-joint excisions, which raged within the memory of the present generation of surgeons both in England and in this country. The conflict is yet too recent, the smoke of battle too thick, for the history of those controversies to be written without risk of giving unmeant offence, if not of doing unintentional injustice. The victory has been won by the friends of "conservative surgery," and it becomes those who have conquered to wear their laurels with modesty as well as with dignity.

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[1] Op. cit., pp. 18, 47.

[2] Op. cit, pp. 48–52.

[3] Park and Moreau, op. cit., p. 81.

[4] Mr. Park's case was not known in France till the next year (1784), when his observations were translated and published in that country by the celebrated Lassus.

[5] Park and Moreau, op. cit., p. 84.

[6] Nouveaux Éléments de Médecine Opératoire, 2e édition, t. ii. pp. 681, 682.

INDICATIONS FOR AND CONTRA-INDICATIONS TO THE OPERATION OF EXCISION IN GENERAL.

Excisions of *joints* may be practised in cases of *wound*, whether by accidents of civil life or by gunshot injury; of *compound dislocation* or of *compound fracture* involving a joint; of destructive *disease of an articulation;* and of *anchylosis.*

Excisions or resections of *bones* may be required in cases of *compound fracture; compound*, or *irreducible, simple dislocation* (in the case of some of the short bones, such as the astragalus); *ununited fracture; deformity* following fracture or other injury; and *disease*, whether *inflammatory* or *neoplastic.*

WOUNDS OF JOINTS.—The applicability of the operation of excision to joint-wounds has been so fully considered in previous portions of this work,[1] that I need not dwell upon the subject here further than to say that, in my judgment, when any operation at all is required, the surgeon's first thought should be of excision, rather than of amputation. Even in the case of the knee, though excision for traumatic causes is less favorable here than in any other locality, I should be strongly tempted to give this mode of treament a trial if the patient were young and healthy, and if the injury were sufficiently limited in extent.

COMPOUND DISLOCATIONS.—I am disposed to agree with Hippocrates and Celsus that, in cases of compound dislocation, immediate excision should, as a rule, be practised, except when the part involved is the knee, when amputation will ordinarily be preferable. I have, however, myself saved a case of compound dislocation of the ankle, without operation, by the use of continuous irrigation, and similar successes are occasionally met with by almost all surgeons. The great advantage of excision in these cases lies in its preventing the destructive inflammatory tension which is almost inevitable when simple reduction has been effected.

COMPOUND FRACTURES INTO JOINTS are also, as a rule, cases for excision (provided that amputation be not required), and for the same reason, viz., the avoidance of injurious tension from the inevitable swelling, and from retention of the products of inflammation. When the knee is the part affected, amputation should, I believe, be resorted to without hesitation; but in the case of the joints of the upper extremity, and of the hip and ankle, I should prefer excision whenever a choice of operations was admissible.

With regard to the *period of operation*, in cases of compound fracture, the same rules may be given as for amputation under similar circumstances, viz., that *primary* excision should be preferred, but that if the golden opportunity of operating before the onset of inflammatory fever has been lost, an effort should be made to temporize until suppuration has been fully established, when a *secondary* excision may be resorted to with more prospect of success than would have attended an *intermediate* operation. This will appear from the following table of determined cases in military surgery, compiled from the figures of Gurlt,[1] and supplemented, as regards the hip and the knee, by those more recently published by Drs. Otis and Huntington.[2]

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[1] By Prof. Andrews in Vol. III. pp. 720 *et seq.*, and, as regards gunshot wounds in particular, by Prof. Conner, in Vol. II. pp. 153 *et seq.*

TABLE SHOWING THE INFLUENCE OF THE PERIOD OF OPERATION ON THE RESULTS OF EXCISIONS OF THE LARGER JOINTS.

Locality of operation.	Period of Operation.								
	Primary.			Intermediate.			Secondary.		
	Cases.	Deaths.	Mortality per cent.	Cases.	Deaths.	Mortality per cent.	Cases.	Deaths.	Mortality per cent.
Shoulder . . .	556	177	31.8	128	68	53.1	614	241	39.3
Elbow	389	84	21.6	113	33	29.2	681	194	28.5
Wrist	39	4	10.3	8	3	37.5	53	12	22.6
Hip	43	40	93.0	60	58	96.7	37	23	62.2
Knee	37	23	62.2	53	46	86.8	31	20	64.5
Ankle	...	...	......	7	3	42.9	123	44	35.8
Aggregates . .	1064	328	30.8	369	211	57.2	1539	534	34.7

Locality of operation.	Late Secondary.			Unknown.			Totals.		
	Cases.	Deaths.	Mortality per cent.	Cases.	Deaths.	Mortality per cent.	Cases.	Deaths.	Mortality per cent.
Shoulder . . .	27	1	3.7	111	21	18.9	1436	508	35.4
Elbow	14	...	......	112	11	9.8	1309	322	24.6
Wrist	7	...	......	12	...	......	119	19	16.0
Hip	4	3	75.0	27	24	88.9	171	148	86.5
Knee	2	2	100.0	8	5	62.5	131	96	73.3
Ankle	1	...	......	2	1	50.0	133	48	36.1
Aggregates . .	55	6	10.9	272	62	22.8	3299	1141	34.6

It will be seen from the preceding table, that the only exception to the rule that primary excisions are the most successful, is in the case of the hip, where secondary excisions gave the best result. But this by no means proves that primary operations should be avoided in these cases. The patients who survive until the secondary period furnish, by the very fact of survival, selected cases which offer an exceptionally favorable prognosis. I have no doubt of the entire correctness of the opinion expressed by Dr. Otis and Dr. Huntington, that "The disastrous results attending cases of indubitable shot-fracture at the hip treated by temporization [a mortality rate of 98.8 per cent.] must induce the surgeon to desist from such an experiment, and to excise primarily rather than submit the patient to the danger of the inflammatory period."[3]

The table embraces no example of *primary excision of the ankle*, but that the primary period is the best for interference in cases of wound of this as of other articulations, is shown by the results of 33 cases tabulated by Dr. Otis and Dr. Huntington from the records of the American War.[4]

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[1] Die Gelenk-resectionen nach Schussverletzungen, u. s. w. Berlin, 1879. See an able analytical review of Prof. Gurlt's work, by Dr. G. M. Kober, U. S. A., in the American Journal of the Medical Sciences, for April, 1881.

[2] Medical and Surgical History of the War of the Rebellion, Part Third, Surgical Volume. Washington, 1883.

[3] Op. cit. Part Third, Surgical Volume, page 126.

[4] Ibid. page 585.

Period of operation.	Cases.	Recoveries.	Deaths.	Undetermined.	Mortality per cent. of determined cases.
Primary	11	8	2	1	20.0
Intermediate	8	5	3	...	37.5
Secondary	9	5	4	...	44.4
Unknown.	5	4	...	1	..
Aggregates	33	22	9	2	29.0

JOINT DISEASE.—It is, however, in cases of destructive disease of the articulations, whether of traumatic or of non-traumatic origin, and whether of simple, inflammatory, or of scrofulous or tuberculous character, that the operation of excision finds its principal application. The indications and contra-indications which the surgeon should consider before deciding upon the propriety of excising a diseased joint, may be briefly stated as follows:—

Excision is indicated (1) when an *articulation is so much diseased* that the recovery of the patient depends upon its removal; under such circumstances, the question is between excision and amputation, and the former operation should certainly be chosen whenever the circumstances of the particular case permit an option. In saying this I am not unmindful that a few surgeons may still be met with, who profess to believe that a stump with an artificial limb is better than a limb of flesh and blood; but these will, I think, be generally found to be gentlemen who have had little, if any, practical experience with the operation which they condemn.

(2) Excision is occasionally proper in cases in which, while the extent of disease is not sufficient to justify an amputation, the *length of time* which would be necessary for the obtaining of a spontaneous cure would be such as of itself to warrant operative interference, or in which the result of a spontaneous cure, if obtained, would be less satisfactory as regards the usefulness of the limb than the result of an operation. In the elbow, for instance, the movable joint afforded by a successful excision, is much preferable to the cure by anchylosis, which is commonly the best that can be hoped for by expectant treatment.

Excision is, on the other hand, contra-indicated (1) by the *extent of osseous disease* being so great that its entire removal would forbid the hope of retaining a useful member, under which circumstances amputation would be preferable. This rule is particularly applicable in the case of articulations of the lower extremity; as regards the arm, provided that the hand be preserved, the bones may be more freely dealt with, and large portions may often be removed without materially impairing the utility of the limb.

(2) Excision is not ordinarily applicable to cases of *acute disease* of the articulations. If it be necessary to interfere at once, under such circumstances, experience shows that an amputation is more apt to be well borne than an excision; an attempt should always be made, however, if the general condition of the patient permit it, to modify the acute course of the disease by appropriate treatment, both constitutional and local, when, if the severity of the symptoms be subdued, and the case assume a subacute or chronic character, exsection may be properly resorted to.

(3) Very extensive *disease of the soft tissues* around a joint, and particularly the existence of peri-articular abscesses, and of long, suppurating sinuses, passing up and down between the muscular sheaths of the limb, undoubtedly

exercise a prejudicial influence upon the progress of a case after excision, by prolonging the time required for treatment, and by thus exposing the patient to the various risks which always attend long-continued suppuration. But such a state of affairs cannot be said to absolutely contra-indicate the operation, and, if the other features of the case be favorable, excision may often be hopefully resorted to, even if the tissues be much infiltrated and the skin fairly riddled with sinuses. I have more than once excised the hip, under such circumstances, with the happiest result.

(4) Excision is contra-indicated in cases in which the patient is either *very young* or past *early middle age.* Children less than five years old are unfavorable subjects for excision, at least of the joints of the lower extremity, on account of their intolerance of the restraint necessary in the after-treatment of these cases; and indeed, as regards excision of the knee, I have in recent years been disposed to fix this limit at a still later period, and I am now chary of attempting a knee-joint excision in a child under nine or ten. On the other hand, the mortality which follows the operation of excision, as we shall see presently, rapidly increases with advancing age—more rapidly, even, than the mortality after amputation; and hence, though brilliant successes have occasionally been obtained by excision in old persons, these results must be considered exceptional, and the prudent surgeon will usually prefer amputation—if any operation be necessary—in patients who have passed the middle period of life. The objection which is often urged against excision in childhood, that it interferes with the future growth of the limb, is more apparent than real. Bœckel, of Strasbourg, from an investigation of more than twenty cases of arrested development, came to the conclusion that the shortening was less due to injury of the epiphyseal cartilages than to disuse of the limb owing to pain or to muscular atrophy; and, as shown by Mr. Barwell at page 359 of the present volume, the arrest of epiphyseal growth is by no means unlikely to occur as a result of inflammation, even in cases treated without operation.

In illustration of this point, I may refer to a case in which I excised the knee of a lady, 30 years of age, sent to me by Dr. Massey, of West Chester; the disease of the joint had begun when she was only seven years old, so that it was of 23 years' standing when she came under my care. The knee was flexed beyond the right angle, and the whole limb, below the knee, very much wasted, and by actual measurement four inches shorter than its fellow. She walked, with great difficulty, by the aid of a crutch or cane, and high-soled shoe, the shortening being so much increased by the flexion of the limb that a sole of seven inches merely enabled her to bring her toes to the ground. By the operation of excision, I was enabled to give this lady a strong and straight limb, and, as with exercise the muscles of the leg became developed, and the ankle strengthened, she was enabled to throw aside her artificial supports; and though a considerable amount of bone had of course been removed at the operation, she was, by the straightening of her limb, now able to walk easily and without fatigue, with a sole of but five inches' thickness, her leg being thus practically two inches longer than it had been before the excision. I have recently heard from Dr. Massey that this lady now—more than six years since the operation—continues in excellent health, and walks without any artificial support whatever.

(5) An impaired state of the general health, particularly if this condition be due to organic disease of the viscera—and especially of the lungs, liver, or kidneys—should always be regarded as a contra-indication to excision. The operation, at least in the lower extremity, usually necessitates long confinement of the patient during the after-treatment, and is apt to be followed by profuse and exhausting suppuration, thus seriously compromising the chances of recovery. Hence, as a rule, if any operation becomes necessary in a case

of joint disease complicated with phthisis, Bright's disease, or amyloid degeneration, amputation will offer the patient a better chance than excision.

ANCHYLOSIS.—It often happens that while *incomplete* or *fibrous anchylosis* has occurred in one portion of a joint, destructive disorganization is progressing at another, and under such circumstances excision may of course be required, as in cases of destructive disease without any attempt at repair. There are, too, cases of fibrous anchylosis, with the limb in a bad position, and complicated by frequently recurring attacks of arthritis, in which excision will prove the best remedy. Such a case was that illustrated by Figs. 734, 735 (page 510), in which I excised the knee many years ago, at the Episcopal Hospital. *Bony* or *complete* anchylosis is usually amenable to milder remedies than excision—subcutaneous osteotomy, as practised by Mr. Adams and Mr. Maunder, or drilling, after the manner recommended by the late Dr. Brainard, of Chicago, commonly proving satisfactory. In some cases of bony anchylosis of the knee, however, a better result may be secured by Gurdon Buck's method of sawing out a wedge-shaped portion embracing the whole thickness of the bone, and containing the femoral condyles, head of the tibia, and patella—what has since been called excision in a block—and in the case of the elbow, excision will prove the best mode of treatment, as permitting recovery with a movable joint, which could hardly be obtained in any other way.

COMPOUND FRACTURES OF THE LONG BONES may occasionally require a resort to resection, either to facilitate reduction, when a fragment protrudes through the wound and cannot be replaced, or when, though the bone is much shattered and comminuted (as by gunshot injury), the destruction of parts is not so great as to necessitate amputation. Except in military practice, however, the operation is seldom required in these cases, it being usually better simply to remove loose fragments and trust the rest to nature; nor does my own experience lead me to recommend resection of the long bones, even in cases of gunshot wound, except in the forearm, when only one of the two bones is injured, and, perhaps, in the fibula. I have with advantage resected the lower jaw, in a case of gunshot injury attended with great splintering and comminution.

DISLOCATIONS OF THE BONES OF THE FOOT may require exsection of the displaced bone, if the injury be compound, or if, though simple, the bone be irreducible and so placed as to interfere with locomotion. The astragalus is the part which most often requires removal under these circumstances, but the question of operation may also arise in the case of the bones of the anterior tarsus.

UNUNITED FRACTURE not unfrequently calls for the operation of resection, which indeed, when performed in the manner recommended by Prof. Ollier and Prof. Bigelow—preserving the periosteum and fastening together the freshened ends of the fragments with a wire suture—constitutes the most certain remedy for this condition, and is one that I have repeatedly resorted to with complete success.

DEFORMITY resulting from badly treated fracture or other injury of a bone may be a cause for resection.

A few years ago, I had under my care, at the University Hospital, a man who as a consequence of fracture of the fibula and contusion of the tibia, followed by osteitis, presented so marked an outward flexion of the lower third of the leg as to seriously interfere with walking. By cutting away a wedge-shaped segment of the tibia, and a small disk of the fibula, I was enabled to bring the bones into good position, and then fastening them with sutures of thick silver wire and placing the limb in a bracketed splint, such as will be hereafter described in connection with excisions of the ankle, I succeeded in obtaining firm union without any reproduction of the deformity, and gave the patient a perfectly useful, though slightly shortened member.

Excision of the astragalus or other tarsal bones has been successfully practised to relieve the deformity of inveterate cases of *club-foot.*

Caries and Necrosis.—Many cases which are described as excisions of the long bones for *necrosis* are in reality nothing more than sequestrotomies, and, indeed, it is hard to conceive of an ordinary case of slow necrosis in which formal excision could be justified; if uncomplicated, the sequestrum should certainly be removed without unnecessary disturbance of the new-formed involucrum, and if this were forbidden by implication of the neighboring joints or other circumstances, amputation would probably be indicated. There are, however, cases of *acute necrosis*, resulting from subperiosteal abscess, in which immediate interference is necessary, and in which removal of the entire shaft of the bone, after splitting the periosteum longitudinally, may permit the preservation of the limb. Brilliant and successful operations of this kind have been recorded by Mr. T. Holmes, Dr. Shrady, and other surgeons.

Caries is usually amenable to milder treatment than removal of the entire bone, but in cases in which the disease is too extensive for gouging, or for Prof. Sédillot's method of *évidement*, subperiosteal excision may be properly resorted to.

Rachitic deformities of the long bones have occasionally been thought to justify resection, but in almost all cases can be remedied either by the use of mechanical appliances or by the less dangerous operation of subcutaneous osteotomy.

Tumors of bones, finally, may become the indication for excision. In the case of the long bones amputation should usually be preferred, though successful resections for myeloid growths of the radius and ulna have been recorded by Mr. Lucas and Mr. Morris. In the case, however, of the round or flat bones—as, for instance, the maxillæ, scapula, or clavicle—excision may properly be performed.

The remarks which have already been made as to the indications and contraindications of excision, in cases of joint-disease, are equally applicable, *mutatis mutandis*, in regard to resection for injuries and diseases of the bones. From them it will be perceived that, while these operations are, in suitable cases, admirable and truly conservative procedures, they are yet, after all, adapted only to selected cases; it is therefore manifestly unfair to attempt, as is sometimes done, to prove that excision is a less grave operation than amputation, by instituting a comparison of their statistical results; the fact being that while the first-named operation is habitually reserved for the more favorable cases, the other is, of necessity, employed for those which offer a less favorable prognosis. Greatly as I admire the operation of excision, and strongly as I deprecate, under all circumstances, the unnecessary sacrifice of a limb, I cannot but believe that, other things being equal, excision is, in most regions of the body, at least as fatal, if not more fatal, than the corresponding amputation.

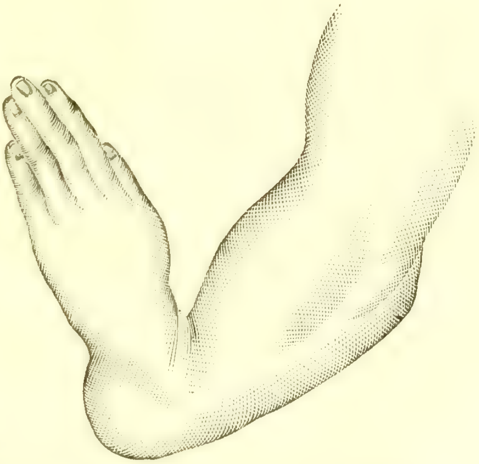
Process of Repair after Excision.

In studying the process by which repair is effected after excision or resection, we must refer for a moment to the means by which the growth of the bones is accomplished in a state of health. Bones increase in *thickness* by proliferation from the inner layer of their periosteal covering, and in *length* through the medium of the epiphyseal cartilages, or, as Ollier has called them, the cartilages of conjunction. Hence, in resections of the shafts of the long bones, it is important to preserve the periosteum, and when this is done, as it can be in cases of acute necrosis, complete reproduction may be effected, although immediately after the operation the limb may have appeared quite limp and boneless. So, too, in operations on the short bones, when the operation can be made subperiosteal, the restoration of the part is much more complete and satisfactory than under other circumstances.

Another great advantage which attends subperiosteal excision in all situations, is that it permits the affected bone to be removed without disturbing the attachments of the various muscles, a matter which is, of itself, of very considerable importance.

In excisions of the joints in young persons, care should be taken not to infringe upon the line of epiphyseal junction, since, if the entire epiphysis be removed, the growth of the limb will be materially interfered with. The annexed wood-cut (Fig. 677), from a patient under my care some years since at the Episcopal Hospital, shows what great deformity may result from epiphyseal injury in childhood. No operation had been performed in this case, but it serves to illustrate the importance of the epiphyses in maintaining the growth of the limb.

Fig. 677.



Deformity from injury of radial epiphysis.

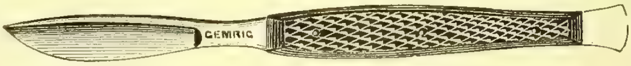
Ollier has pointed out the interesting fact that tumors of the long bones find their favorite seats at that extremity from which the principal growth of the bone proceeds, and has shown the dependence of both events upon the particular direction of the nutritious artery. Thus, the humerus grows mainly from its upper epiphysis, and the bones of the forearm from the epiphyses near the wrist, while in the lower extremity the growth of both leg and thigh is chiefly effected by the epiphyses in proximity to the knee. Hence the risk of hindered growth after excision is comparatively slight at the elbow, hip, and ankle, and is most to be dreaded in operations at the shoulder and wrist, and, above all, at the knee, since shortening is of much greater consequence in the lower than in the upper extremity. On the other hand, since at the knee firm, bony union is sought for, it is less important to preserve the periosteum in excisions of this joint than in those of the other articulations, where it is wished to preserve the power of motion, and where, therefore, a more or less perfect reproduction of the articulating extremities is hoped for.

Repair after excision of the knee, or after any other excision which is followed by bony union, and repair after resection in the continuity of the long bones, is effected in the same manner as repair after compound fracture. The sawn ends of the bones undergo a retrograde metamorphosis into granulation-tissue, and the granulations from the approximated surfaces coalescing, osseous matter is again deposited, and in time complete synostosis results. In the case of the shoulder, hip, or elbow, though, in some few instances, a new capsule, and even a new synovial membrane, seem to have been formed, in the immense majority of cases union of the resected bone-ends is effected through the medium of strong cicatricial bands, analogous to those met with in fibrous anchylosis. A similar substance fills the gap after excisions of the short bones, such as the calcaneum and astragalus (when the operation is not done subperiosteally), and it is surprising to see, in these cases, what a firm mass fills the place of the exsected bone, and how little deformity, in many instances, results.

Operation of Excision in General.

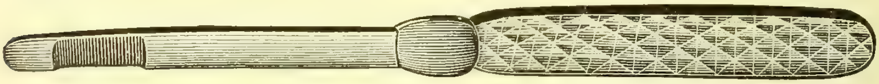
Instruments Employed in Excision.—The *knives* required for excisions are strong scalpels and bistouries; a good form for the first-named instrument is that shown in Fig. 678, the handle being armed with a steel raspatory, which is convenient for separating the periosteum. Another very useful knife is that shown in Fig. 679, with a probe-point, very heavy back, and limited cutting edge; it can be used freely in the deep parts of the wound without risk of wounding large vessels or other important structures, an accident

Fig. 678.



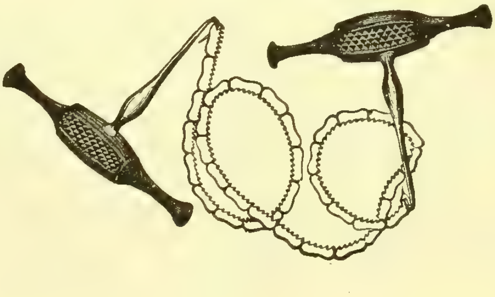
Strong scalpel with raspatory, for excisions.

Fig. 679.



Erichsen's probe-pointed knife with limited cutting edge, for excisions.

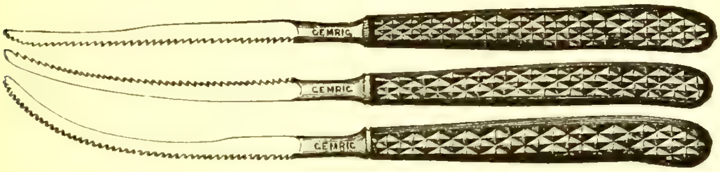
Fig. 680.



Chain-saw.

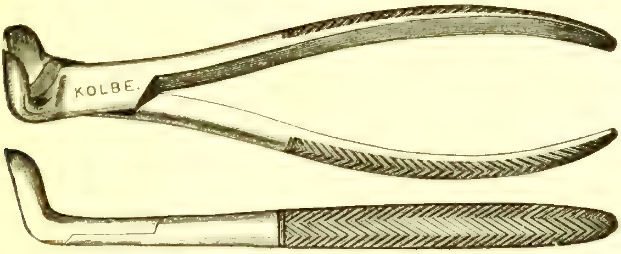
which has occurred (through using sharp-pointed knives) in the hands of very eminent operators, and which may cause loss of the limb, if not of the patient's life. The most useful forms of *saw* are that known by the name of Mr. Butcher,[1] and the chain-saw (Fig. 680), the merit of introducing which is divided between Dr. Jeffray, of Glasgow, and Dr. Aiken, of Edinburgh;[2] small but thick-bladed saws, such as are shown in Fig. 681, are also useful in some cases. *Bone-forceps*, of various sizes and shapes, will be required, the most important being the strong-cutting pliers of Liston,[3] and the lion-jawed forceps of Ferguson.[4] The angular (Fig. 682) are sometimes more convenient than the straight Liston's forceps, and for certain operations about the jaws the instrument shown in Fig. 683 will be found of value. Butcher's knife-bladed forceps (Fig. 684), are particularly useful for cutting away the thickened synovial membrane in excisions for gelatinous arthritis of the knee and

Fig. 681.



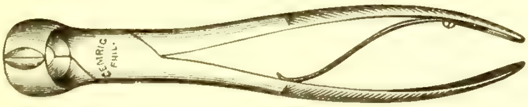
Small saws for excisions and resections.

Fig. 682.



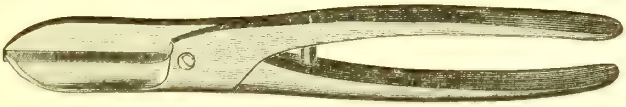
Angular cutting forceps.

Fig. 683



Cutting forceps for operations on the jaws.

Fig. 684.



Butcher's knife-bladed forceps.

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[1] See Vol. I. p. 573, Fig. 127.

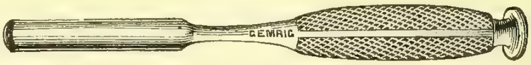
[2] Park and Moreau, op. cit., p. 175.

[3] See Vol. I. p. 573, Fig. 128.

[4] See Vol. I. p. 573, Fig. 129.

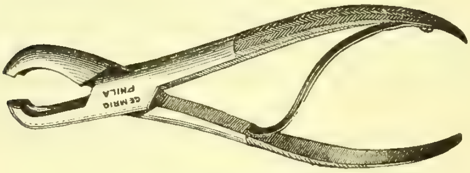
elbow. Should caries extend to a point beyond that at which it is thought prudent to apply the saw, it may be dealt with by means of the *gouge* (Fig. 685), or *gouge-forceps* (Fig. 686). or the *osteotrite* or burr-head rasp (Fig. 687).

Fig. 685.



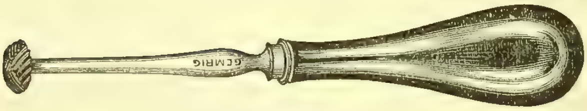
Bone-gouge.

Fig. 686.



Gouge-forceps.

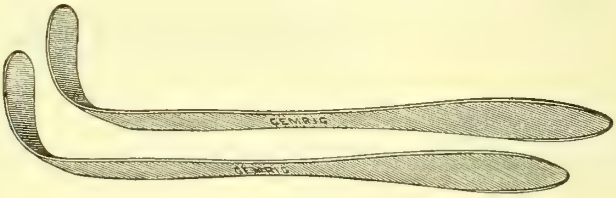
Fig. 687.



Osteotrite or burr-head rasp.

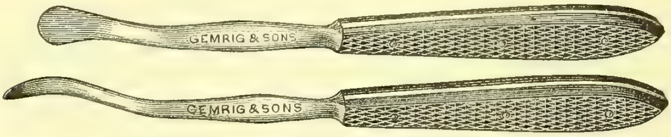
Other instruments which should be at hand are a pair of *retractors* (Fig. 688), for protecting the soft parts and facilitating the exposure of the bone, a *periosteal elevator* (Fig. 689), and, if an ordinary saw be used, a *resection-sound*,[1] Dr. Prince's probe-pointed grooved retractor, or, which in some cases will answer every purpose, an ordinary broad lithotomy staff, grooved on the back, which may be readily slipped under the bone and then turned with its convexity upwards. When, however, the Butcher's or chain-saw can be used, these

Fig. 688.



Retractors.

Fig. 689.



Periosteal elevators.

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[1] See page 62, Fig. 591.

instruments will be unnecessary; the great advantage of the *Butcher's saw* is that its blade can be so reversed as to cut from below upwards, and in doing this care must be taken that the teeth of the saw point *backwards* instead of *forwards;* the obvious reason for this is that in sawing *downwards*, the force of the arm is applied in *pushing*, but in sawing *upwards*, in *pulling*, and the blade of the instrument must be arranged accordingly. When the *chain-saw* is used, it may be simply slipped over the part to be removed, after disarticulating, or, in operations on the continuity of the long bones, may be adjusted by detaching one of the handles and tying the chain to a strong curved needle, which can be guided around the bone, or by employing an ingenious conductor devised for the purpose by the late Dr. Gurdon Buck, of New York.

General Rules for Excision.—The particular operative procedures which are required for excision or resection in the different regions of the body, vary of course with the locality, and with the special parts which are to be removed. It may be said, however, in general terms, that the external incisions, while not needlessly large, should be sufficiently free to allow fair exposure of the bones, and that they should lie, as much as possible, in the lines of the intermuscular spaces, so as to avoid unnecessary destruction of tissue. It is well, if convenient, though it is by no means essential, to make the incisions include the openings of any sinuses that may be present; they should always be so placed as to avoid any risk of injuring the principal bloodvessels and nerves. The periosteum should, for reasons already given, be preserved, when it is practicable to do so, and, as a rule, the amount of bone removed should be as small as may be consistent with the complete extirpation of the diseased structure. A good plan, in excising joints, is to take away only a thin layer of bone with the saw, and then to attack any remaining patches of caries or necrosis with the gouge, osteotrite, or trephine. The line of epiphyseal junction should not be encroached upon in operations upon children, lest the subsequent growth of the limb should be interfered with; and even in cases of adults it is important to avoid laying open the medullary canal, implication of which greatly increases the risk of destructive osteomyelitis—an affection which, as is well known, is often followed by pyæmia and death. Care must be taken, in all excisions, not to mistake bone which is merely inflamed and softened (in a condition of *medullization*) for that which is actually carious, nor bone which, as the result of inflammation, is simply thickened and roughened, for that which is necrosed.

No matter how much altered in appearance the skin may be—even if it is riddled with sinuses—it and the superficial fascia should be preserved entire; the flaps, though they may at first seem redundant, will ultimately shrink and resume their natural condition. The degenerated synovial lining of the articulation may, however, advantageously be cut away with the knife-bladed forceps; and Volkmann, of Halle, even goes so far as to recommend complete "extirpation" of the joint capsule.

I am not in the habit of employing any tourniquet, or other means of controlling the circulation, during ordinary excisions, believing it safer to go slowly, and tie, if necessary, each bleeding vessel as it is cut. There are, however, no large arteries divided during the operation, and it not unfrequently happens that, when the incision is completed, no ligatures are required. The only case in which I have ever seen fatal hemorrhage after a joint-excision, was one at the Children's Hospital, in which my colleague, the late Dr. H. Lenox Hodge, used the Esmarch bandage—then a surgical novelty—in a case of excision of the knee. The operation, in which I assisted Dr. Hodge, presented no complication, and the wound appeared perfectly dry when it was closed; but a few hours afterwards, when the patient (a little girl) had become warm in bed, reactionary hemorrhage set in, and, in spite of all the measures that were adopted—including, finally, opening and plugging the wound with lint—bleeding continued, until the child fell into a state of exhaustion from which she never rallied.

Hemorrhage having been controlled, the wound should be closed with sutures—leaving, however, ample openings for free drainage, which should be promoted, if necessary, by the introduction of Chassaignac's tubes—and then lightly dressed with oiled lint, or with whatever material the surgeon may fancy, and the limb supported with a bracketed splint, or otherwise, in such a manner that the wound itself may be examined and dressed without unnecessarily disturbing the neighboring parts. If the olive-oil dressing be used—and I know of nothing better—it should be covered with oiled silk to keep it moist, as it is desirable that the wound should not be meddled with for at least forty-eight hours after the operation.

The after-treatment of excisions is that of operations in general.[1] In the case of adults, anodynes will probably be required during the first few days, but I have not usually found them necessary with children. Carbonate of ammonium should be given in from two to five-grain doses every hour, or every two hours, until reaction is fully established, and then a simple febrifuge during the period of traumatic fever; after a few days quinine may be added, and may be combined with iron if suppuration be very free. Milk is the best article of diet at first, and, if there be nausea, should be slightly diluted with lime-water. In the later stages of the case concentrated food will be required, and probably alcoholic stimulants in quantities proportioned to the patient's age and general condition.

The most frequent causes of death after excision I have found to be tuberculous and amyloid disease—causes connected therefore rather with the patient's state before operation than with the operation itself. If it be evident that the general health is failing to such an extent that repair cannot be hoped for, the surgeon should advise amputation, which may often be performed under these circumstances with the most gratifying results. But as long as the patient's strength is fairly well maintained, the attempt to save the limb should not be discontinued on account of apparent want of improvement in the local condition; a year, or even longer, is not too much time to devote to the after-treatment of a hip or knee excision, and even if caries, necrosis, or deformity should recur, all hope should not be abandoned, for a *re-excision* may sometimes be successfully practised in such a case.

SPECIAL EXCISIONS.

Excisions of Bones of the Head and Trunk.

The operation of *trephining the skull* is an example of partial excision, and is sometimes treated of as such in systematic works on operative surgery. Its interest and importance, however, are so clearly dependent on the proximity of the brain to the part operated upon, that I shall not consider it in this place, but will refer the reader to the article on Injuries of the Head, where it can be more appropriately dealt with. Similarly, the operation of trephining or *resection of the vertebræ*, is almost exclusively of interest in connection with traumatic lesions of the spine—though the operation has occasionally been attempted in cases of disease, as by Heine, Roux, Holscher, Dupuytren, and Jacobi, and more recently, for the evacuation of spinal abscesses, by Israel and A. Jackson—and I shall therefore refer the reader for its consideration to the article on Injuries of the Back, where the history and statistics of the procedure are fully set forth, merely adding here that, if the operation is to be done at all, it can be best accomplished, as recommended by Dr. McDonnell,[1] by making a free and deep incision, and then dividing with strong-cutting pliers the bony laminæ on either side of the spinous process of the injured vertebra, and, after taking away a single arch, removing any additional portions of bone with the ordinary gouge-forceps.

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[1] See Vol. I. p. 452.

In certain cases of severe injury of the face, chiefly as the result of gunshot wound, it may be necessary to remove shattered portions of bone, and smooth off projecting fragments; but for such exceptional and irregular resections as these, no definite rules can be given. Again, in certain cases of nasal tumor, the bony orifice of the nostril may be enlarged by clipping away its outer wall with gouge-forceps. But the only excisions of bones of the face, which I shall describe in this article, are those of the superior and inferior maxillæ.

Excision of the Upper Jaw.—Trephining of the antrum, and even partial excision of the superior maxilla, appear to have been practised occasionally during the last century[2] and the early part of this; but the first proposal to excise the whole upper jaw for tumor appears to have been made by Lizars, of Edinburgh, while the first surgeon who is known to have actually accomplished the operation was Gensoul, of Lyons, in 1827.[3] Lizars and the elder Textor repeated the operation in 1828, and Lizars again, and Léo in 1830. Gensoul, alone, had removed the jaw seven times up to 1833. The operation is chiefly required in cases of tumor, either involving the jaw itself or situated behind it (naso-pharyngeal polypus), *temporary* or *osteoplastic resection* being by some surgeons preferred to complete excision under the latter circumstances.

Several varieties of incision have been practised for the removal of the upper jaw. Gensoul began with an incision extending from the inner angle of the orbit, downwards, through the upper lip, which was divided opposite the canine tooth; a second incision extended transversely outwards from the first, at the level of the nostril, to within a short distance of the lobe of the ear; and a third passed upwards from the end of the second to the external angle of the orbit. Lizars employed an incision from the angle of the mouth across the cheek to the malar bone, supplementing this cut, if more room was needed by one through the lip into the nostril, and by a short longitudinal incision at the outer extremity of that first made. Liston's method consisted in making one incision from the external angular process of the frontal bone through the cheek to the corner of the mouth; a second along the zygoma, joining the first; and a third from the nasal process of the maxilla, detaching the ala of the nose, and cutting through the lip in the mesial line. Velpeau's operation possessed an advantage over all of these, in its greater simplicity; a single curved incision, convex downwards, was carried from the angle of the mouth, upwards and outwards, to the malar bone, or if necessary to the external angle of the orbit; but this incision does not, it seems to me, give sufficiently ready access to the deeper and central portions of the wound, in case of hemorrhage, and though it is still a favorite with French surgeons, it is, I think, inferior to that which was introduced and recommended by Sir Wm. Fergusson, and which I have always found perfectly satisfactory.

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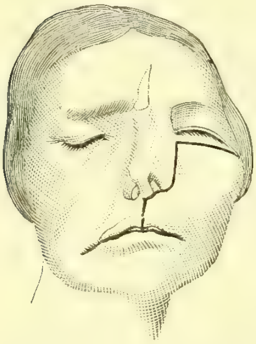
[1] Dublin Quarterly Journal of Medical Science, August, 1866.

[2] One of the most important operations of this kind was performed in 1820, by Dr. Jameson, of Baltimore. The first partial excision of the upper jaw is attributed to Acoluthus, in 1693.

[3] Priority has been claimed for the late Dr. Alexander Stevens, of New York, but no account of his operation appears to have been published until many years afterwards.

Fig. 690.

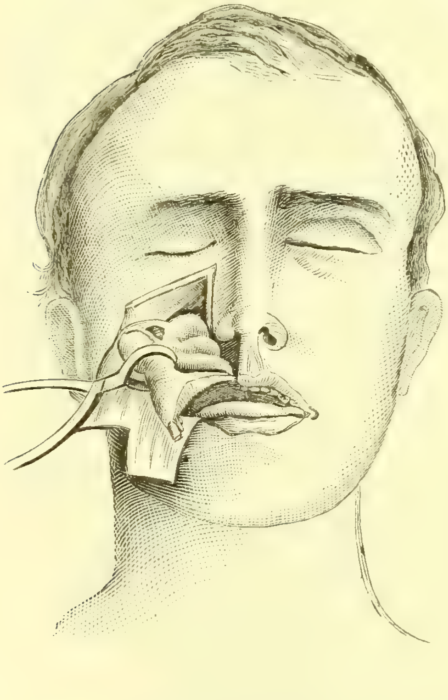


Incision for excision of the upper jaw by Fergusson's method.

Fergusson's operation (Fig. 690) consists in dividing the upper lip in the mesial line, laying open the nostril corresponding to the side of the tumor, carrying the knife from the root of the ala, between the side of the nose and the cheek, as far as the nasal bone, and then cutting transversely, opposite the lower border of the orbit, to the zygomatic process of the malar bone. The flap thus marked out being dissected up, sufficient room is furnished for the removal of the largest tumor. All of the integument covering the tumor should be scrupulously preserved, as if any "button-hole" be made in the flap, the subsequent contraction will leave a fistulous opening.

The tumor having been exposed, and the soft palate, if healthy, divided by a transverse incision, the bony attachments of the jaw may be severed with a chain-saw or small resection-saw, or, which I think much better, with the strong cutting forceps known as Liston's.[1] The lateral incisor tooth of the affected side having been extracted, the blades of the forceps are made to cut a groove in the alveolus, and then one blade is applied in this groove and the other to the floor of the nostril, when, the handles being forced together, the hard palate is cut through at a single stroke. The malar bone is next cut across into the spheno-maxillary fissure; or, if this bone is itself involved in the disease, its frontal and orbital processes, and the zygoma, are similarly divided. Lastly, one blade of the forceps is introduced into the nostril at its upper part, and the other into the orbit (the eye and surrounding tissues being held out of the way with the handle of a knife or a retractor), and the inner angle of the orbit cut across. The mass may now be seized with the lion-jawed forceps of Fergusson, and firmly depressed, fracturing the posterior attachments of the jaw, when removal is readily completed with a few touches of the knife. (Fig. 691.) Hemorrhage having been checked by the ligation of the internal maxillary

Fig. 691.



Excision of the upper jaw.

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[1] See Fig. 128, Vol. I. p. 573, and Fig. 006, *supra*.

artery (if it can be seen) and of any other vessels that are found bleeding, or by the application of the hot iron, the external incisions should be accurately adjusted with the hare-lip or shotted suture. A piece of lint, wet with glycerine and water, and laid over the part, is all the dressing that is needed.

Partial excision of the jaw may, in cases of non-malignant growth, often be substituted for complete extirpation; thus, on the one hand, the orbital plate may be preserved, a groove being cut with the saw across the bone below the orbit, and the cutting forceps then applied in the same line; or, on the other hand, the alveolus and hard palate may be left, the bone being cut across above these, and the rest of the operation completed in the ordinary manner. Fergusson suggested that it might be sometimes advisable to cut into the centre of the diseased mass, and then work outwards with gouge and gouge-forceps, instead of resorting to formal excision. In cases of *small tumor*, and in those of *necrosis*, removal may often be effected from within the mouth, without making any external wound whatever, and Dr. Hutchison, of Brooklyn, has even succeeded in extracting through the mouth, in a case of necrosis, the whole upper jaw and malar bone. Linhart, of Berlin, has thus removed the greater portion of both upper jaws, while preserving the muco-periosteal covering of the hard palate and the incisor teeth.

The *statistics* of excision of the upper jaw are quite as favorable as could be expected, in view of the severity of the operation. Of 84 terminated cases of the operation, referred to by O. Heyfelder, 51 ended in recovery, and 33 in death or relapse (39 per cent.); and other authors give a still more favorable picture. Thus, Prof. Agnew, from an analysis of a large number of cases collected for him by Dr. Hunter, finds that 120 operations gave 99 recoveries and only 21 deaths (17.5 per cent.), while 20 cases tabulated by Ohleman, of Bremen, give the high proportion of 17 recoveries, or 85 per cent. Partial excision, though less grave in the immediate results of the operation, is more often followed by fatal recurrence: 83 terminated cases referred to by O. Heyfelder, gave only 48 recoveries and 35 deaths or relapses (42.1 per cent.). Hence the inference is very clear that, in cases of malignant disease, total excision should be preferred. I have myself had occasion to remove the entire upper jaw in three cases, two of which ended in recovery, while the third proved fatal from secondary hemorrhage. Another case, in which I removed all of the jaw except the orbital plate, as a preliminary to the extirpation of a very large pharyngeal tumor attached to the base of the skull, also ended fatally, apparently from the shock of the latter operation.

The principal *risks* which attend excision of the upper jaw appear to be excessive *hemorrhage*, *shock*, and suffocation from the *entrance of blood into the air-passages*.

(1) *Hemorrhage* is always pretty free in the early stage of this operation, though less when Fergusson's median incision is adopted than when the cheek is laid open, and the facial artery cut therefore where it is of considerable calibre. The bleeding may be temporarily arrested by pressure, or by the application of a clip or serrefine, but if the patient is under the influence of an anæsthetic, so that haste is not important, it is as well to pause, and tie each vessel as it is divided. At the end of the operation, there is again free hemorrhage from the internal maxillary artery or its branches, and if there should be any difficulty met with in applying ligatures, the bleeding points should be promptly and thoroughly seared with the hot iron, which should always be in readiness. As a prophylactic against hemorrhage, Lizars, and others of the older surgeons, ligated the common carotid artery of the affected side as a preliminary procedure; but this plan has been long since abandoned as unnecessary, and as in itself adding considerably to the dangers of the operation. Digital compression of one or both carotids by the hands of an assis-

tant may, however, be employed with advantage. Ligation of the carotid may be rendered necessary by secondary hemorrhage, as in cases recorded by Mr. Wagstaffe and by Prof. W. H. Pancoast, of Philadelphia. Sir William Fergusson suggested that, as the chief source of bleeding was from the external wound, the ascending process of the superior maxilla, with the alveolus and hard palate, might be notched, if not entirely divided, before cutting into the cheek at all, thus completing the most tedious stage of the operation before making any incision into those parts which were most vascular.

(2) *Shock* is not as much a source of danger in cases of excision of the jaw alone, as in those, like my fourth case above referred to, in which the jaw is removed as a preliminary step in the extirpation of retro-maxillary tumors. It is probably diminished by the employment of anæsthesia.

(3) The *entrance of blood into the air-passages*, causing suffocation, is, on the other hand, no doubt more likely to occur when the patient is unconscious from the use of chloroform or ether, than if no anæsthetic be employed. It proved the cause of death in a case of retro-maxillary tumor operated on by Sir Prescott Hewett. To prevent such an accident, anæsthesia should not be pushed further than is really necessary, particularly in the latter stages of the operation, and an assistant should constantly clear out the mouth and pharynx with small sponges mounted upon short sticks. Nussbaum, regarding this as the chief source of danger in operations upon the jaw, advises the preliminary performance of a temporary tracheotomy, the glottis to be closed with a piece of oiled lint, and the anæsthetic to be administered through a tracheal tube. This plan has, with various modifications, been employed also by several other surgeons, but, I confess, seems to me adapted rather to complicate than to facilitate the operation; and I can but say the same of Rose's and Burow's suggestion, that the patient's head during the operation should be thrown backward so far as to allow the blood to escape from the nostrils. Gluck and Zeller advise that the trachea should be divided transversely between its third and fourth rings, a few days before the principal operation, and that its lower end should be fastened externally. The continuity of the windpipe is ultimately restored by a final operation after convalescence from those which have preceded it. This procedure is said to have been successful in dogs, and seems to me an experimental mode of treatment which might well be reserved for the *corpora vilia* of those animals. Trendelenburg and Gerster have devised ingenious tracheal tampons, to be used after tracheotomy, for preventing the entrance of blood and permitting the maintenance of anæsthesia through the tracheal wound. Stimson employs a tube to plug the larynx and pharynx during the operation, but introduces it through the mouth, and thus avoids the necessity of opening the trachea.

The *use of an anæsthetic*, in the operation of removing the upper jaw, has been objected to by many surgeons, as likely to increase the danger of the procedure; but I think that with care in administration, the risk of anæsthesia may be avoided, and that the shock is apt to be less than if no anæsthetic be used, and, indeed, the operation is so dreadful a one to the patient, that I should hesitate to propose it without offering the benefits of anæsthesia. As to the choice between ether and chloroform, the latter agent is commonly preferred, on account of its vapor not being inflammable by contact with the hot iron, which is often required in the ultimate stages of the operation. But of late I have given the preference to ether in these operations, as in all others, finding that there is no risk of setting the patient on fire if only the precaution be taken to remove the anæsthetic from his face a few seconds before the cautery is applied. I have the patient thoroughly etherized before beginning, and then renew the anæsthesia after the tumor is fully exposed and bleeding from the external vessels arrested; then the ether-cone can be entirely removed while the operation is completed, and the hot iron used if necessary. If it be required, a few whiffs may be again administered before closing the external wound with sutures.

Excision of Both Upper Jaws.—Removal of the *greater part* of both upper jaws was first accomplished by Rogers, of New York, in 1824, but the first *complete* operation of the kind was done by the elder Heyfelder, twenty years subsequently. The incision for this operation, which is one of the gravest character, consists in a median division of the upper lip, with separation of both nostrils and transverse prolongations below the borders of the orbits—a duplication, in fact, of the operation advised for the excision of either jaw separately. When portions only of the maxillæ are to be removed, a plan suggested and successfully employed by Dr. Porter, of Boston, may be resorted to. This consists in making a Y-shaped incision, the leg of the Y dividing the upper lip and its arms entering the nostrils, which can then be pushed upwards so as to afford a considerable amount of room. The recorded *statistics* of this severe operation represent a mortality so moderate as to excite the suspicion that some fatal cases may not have been recorded, twenty-three cases tabulated by H. Braun giving but five deaths (21.7 per cent.). The figures are as follows:

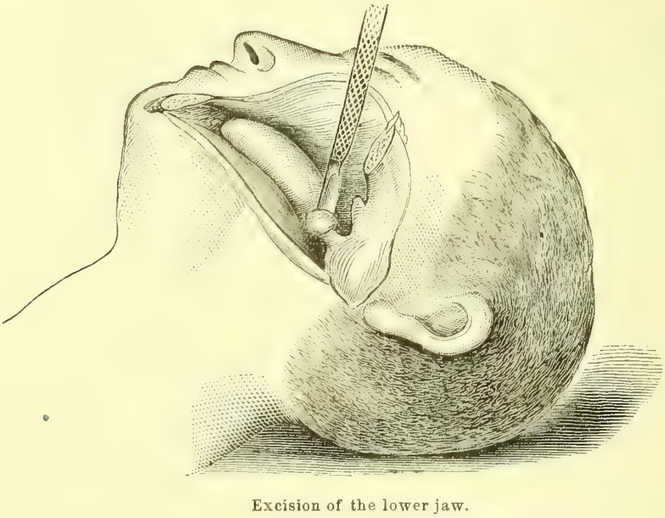
Nature of operation.	Whole number of cases.	Recovered.	Died.
Complete extirpation for tumor	11	7	4
Partial or consecutive extirpation for tumor .	5	5	...
Excision for necrosis	7	6	1

Temporary or osteo-plastic resection of the upper jaw, an operation designed to facilitate the excision of retro-maxillary growths without removing the bone, was suggested by Huguier in 1852 and 1854, but was not practised until about seven years subsequently, when Langenbeck and himself both operated at about the same time. Langenbeck, after making the necessary external incisions, divided the *upper* from the *lower* portion of the jaw, sawed through the connections of the former except at its nasal side, where it was left attached; and then turned it forcibly *inwards*, replacing it after the growth behind it had been removed. Huguier severed the *lower* from the *upper* portion of the jaw, and then forced the former, which retained its palatal attachments, *downwards* and inwards. Roux, of Toulon, suggested a procedure for the temporary displacement of the *whole* upper jaw, apparently in an *upward* direction; but he did not apply his operation on the living subject. Cooper Forster, finally, has practised osteo-plastic resection by displacing the maxilla *outwardly*. One or other of these operations, usually Langenbeck's, has been occasionally employed by other surgeons, including Esmarch, Wagner, Simon, Hill, and Verneuil, and in the majority of cases, apparently, with favorable results. In a case recently recorded by my colleague, Professor Agnew, the displaced jaw became spontaneously separated nine days after the operation, and was removed through the mouth as a sequestrum. Professor Cheever, of Boston, has *twice* operated successfully *on the same patient;* and this surgeon was the first to extend the method of osteo-plastic resection to *both upper jaws*. This case terminated fatally on the fifth day, but a similar operation, in the hands of Professor Tiffany, of Baltimore, has since proved completely successful.

Excision of the Lower Jaw.—As in the case of the upper jaw, when the operation is required for necrosis, the diseased bone may often be removed through the mouth without external incision, and Dr. Perry and Dr. Boker have in this way each succeeded in removing the entire maxilla. In cases of non-malignant tumor, too, incision may sometimes be accomplished without external wound, as was twice done successfully by the late Mr. Maunder; and in any case of this kind it is very desirable, in order to preserve the symmetry of the face, to leave, if possible, the base of the jaw untouched—a mode of dealing with these growths which was practised long since by the late Dr. J. Rhea Barton, of Philadelphia, and the importance of which has been more recently insisted upon by Mr. Heath. If, however, the whole thickness of the bone on one side be involved, excision may be conveniently performed by making a single incision along the base of the jaw, prolonging the wound, if necessary, in a line corresponding to the position of the ascending ramus, and curving its anterior extremity upwards, toward, but not through, the prolabium. If the portion of bone which is to be removed should extend beyond the median line of the jaw, it would be necessary to pass a ligature through the tip of the tongue, so as to prevent its falling backwards when the muscles of the floor of the mouth were divided. The facial artery is necessarily cut in the first incision, and should be immediately secured before proceeding further with the operation. The flap, formed as above directed, should now be carefully dissected up, and, after extracting a tooth on either side of the tumor, the inner face of the jaw should be cautiously cleared by separating the soft tissues of the mouth. The bone may then be divided on each side with the chain-saw, or, if preferred, a deep groove may be cut through the alveolus with a small, straight saw, and the section completed with cutting pliers. The part to be removed is then seized with the lion-jawed forceps and wrenched out of its place, any remaining attachments being severed with a few touches of the knife.

If the angle of the jaw and ascending ramus be involved in the disease, it will be necessary to disarticulate the bone upon that side. Under these circumstances the incision must be extended upwards as far as the articulation, when the bone, having been cut through in front of the tumor, is cleared by cautious dissection and then pushed downwards, in such a way as to render tense and thus facilitate the division of the attachment of the temporal muscle to the coronoid process; the jaw being now twisted somewhat out-

Fig. 692.



Excision of the lower jaw.

wardly, the joint can be opened from the front, and disarticulation completed. (Fig. 692.) The edge of the knife must, throughout the operation, be kept close to the bone, lest the trunk of the facial nerve, or the internal maxillary, or even the external carotid artery, should be accidentally wounded. Ligatures having been applied to the bleeding vessels, and hemorrhage from the bone having been, if necessary, checked by the use of the Monsel's solution or the hot iron, the external wound is closed with sutures. If there is any tendency to retraction of the tongue, it should be kept well pulled forwards, by fastening externally the ligature which was passed through it, with strips of adhesive plaster. Until the wound has united, the patient's diet should be limited to liquid food, which may, if necessary, be administered through a tube.

The portio-dura nerve and the parotid duct are occasionally divided in this operation, and temporary facial paralysis, and sometimes a troublesome parotid fistula, therefore result. To avoid the risk of these complications, Dr. Lizars, of Toronto, recommends, instead of the incision above described, one passing from the commissure of the lips outwards towards the ear; he finds that disarticulation can be readily effected from within the mouth when its orifice is thus enlarged.

Metallic caps, arranged to fit the teeth of the remaining portions of the jaw, and connected by a spring to a similar appliance fitted to the teeth of the upper jaw, are sometimes employed to prevent the part from becoming disturbed by the action of the muscles. I have not, however, found it necessary to apply such an apparatus in those cases in which I have operated, and according to Mr. Heath it is never required, since the bone quickly resumes its normal position without assistance.

Removal of the entire lower jaw may be effected by means of a U-shaped incision dividing both facial arteries, as advised by Sir William Fergusson; or, as preferred by Mr. Heath, the lower lip may be split in the median line, and the flaps dissected back on either side.

Partial excisions of the lower jaw, in cases of gunshot injury, appear to have been practised by Desault and Fischer, in the latter part of the last century, but the first case in which partial removal of this bone was performed for tumor, was that of Deaderick, of Tennessee, in 1810. Ten years afterwards, according to O. Heyfelder, disarticulation of half the jaw was effected by a surgeon named Palm, while extirpation of the entire jaw, at one sitting, appears to have been first performed by Blandin, in 1848. The results of excision of the lower jaw are very favorable. I have not had occasion to remove the entire bone, but have excised large portions in six or seven cases, four of which were disarticulations, and only once with an unfavorable result. This was a case of malignant disease, in an old man, and it was also necessary to remove part of the floor of the mouth, the side of the tongue, and a portion of the palate; death occurred two days subsequently. The most extensive statistics of lower-jaw excision, with which I am acquainted, are those collected by Weber, which I borrow from the sixth edition of Prof. Gross's System of Surgery:—

Nature of operation.	Whole number of cases.	Cured.	Relapsed or died
Complete extirpation	20	19	1
Disarticulation of half the jaw . . .	153	117	36
Excision in continuity	246	200	46
Aggregates.	419	336	83

Taking all the cases together, the proportion of deaths and failures is only 19.8 per cent.

Partial excision of the lower jaw is sometimes performed in cases of *anchylosis*, or of *closure of the jaws* from contraction following a burn, etc. *Esmarch's operation* consists in removing a wedge-shaped portion of bone, three-quarters of an inch wide at its upper part and an inch below, from the horizontal ramus of the jaw in front of the ascending cicatrix. According to Schulten, 40 cases of this operation gave only 2 deaths; but, on the other hand, only 15 permanent recoveries. Failure is apt to ensue from the parts coming together again and gradually closing the gap, as occurred in a case operated upon by the late Dr. Gurdon Buck, of New York, although he removed no less than an inch and a half of bone. Humphry, Bottini, Little, and Abbe, have successfully excised the *condyle of the lower jaw* for anchylosis of the temporo-maxillary articulation.

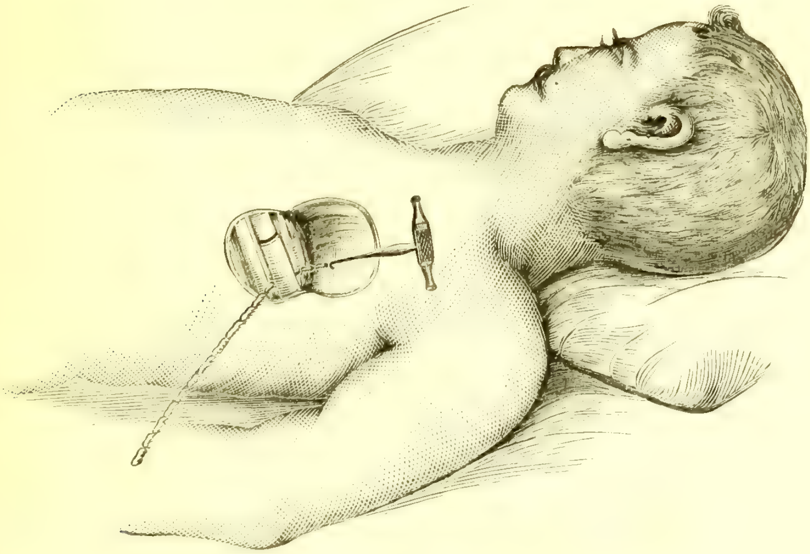
Excisions of the Sternum.—Trephining of the sternum in cases of *caries* or *necrosis*, is an operation which dates back to the days of Galen. The same operation has been employed in cases of *mediastinal abscess*, but cannot be recommended in that affection, as the pus can be more safely evacuated by an incision alongside of the bone. Larrey removed about half of the sternum in a case of *compound fracture*, and Linoli, an Italian surgeon, excised the ensiform cartilage, which was bent backwards, to relieve *uncontrollable vomiting;* though the peritoneal cavity was opened, the patient made a rapid recovery, and is said to have been permanently cured. These partial excisions seem to have been quite successful, 18 terminated cases, tabulated by O. Heyfelder, having given 17 recoveries and only one death. The only case with which I am acquainted in which the *entire sternum* has been removed, is that recently recorded by König. In this remarkable case, the whole sternum is said to have been excised on account of a sarcomatous tumor by which it was occupied; the pericardium and both pleural cavities were opened in the operation, the wound became gangrenous, and the heart was afterwards surrounded with pus; notwithstanding this, the wound slowly healed, and the patient ultimately recovered. Küster has also resorted to resection of the sternum to facilitate the removal of a mediastinal tumor.

If it be thought proper to resort to excision of the sternum, partial or complete, the bone may be exposed by a longitudinal, a T-shaped, or a crucial incision. If the whole bone is to be removed, the costal cartilages may be carefully divided close to the sternum with strong knife or cutting pliers, retractors or the "resection-sound" being interposed to prevent injury of the pleuræ. The bone can then be drawn forwards, and cautiously disarticulated from the clavicles. For partial excisions, it is more convenient to begin by taking away one or more disks of bone with the trephine, and then to complete the operation with the gouge or gouge-forceps.

Excisions of the Ribs.—*Partial excisions* of the ribs have been familiar to surgeons since the days of Celsus, and *complete excisions* of floating ribs are attributed to Fiori and the elder Heyfelder, the first-named surgeon's case having terminated successfully, but the other's patient having died from peritonitis. The operation has been usually practised in cases of *caries* or *necrosis*, *compound fracture*, or *hemorrhage from an intercostal artery;* of 37 cases referred to by O. Heyfelder, only 8 proved fatal. Resections of the ribs for *tumors* have been practised by several surgeons, including Langenbeck, Warren, McClellan, Gibson, Kolaczek, and Fischer. A remarkable case has been recorded by Alsberg, in which, besides portions of several ribs, a segment of the diaphragm was excised, and cases of rib-excision followed by partial removal of the lung are attributed to a surgeon named Suif, and to Dr. Milton Antony, of Georgia. Resection of one or more ribs for *empyema*, as a substitute for the use of a drainage tube after paracentesis, appears to have been first employed, in this country at least, by the late Dr. Warren Stone, of New Orleans. The operation has been since strongly recommended by Roser, Peltavy, and Estlander, and has been practised, usually with good results, by numerous surgeons, including T. G. Richardson, Simon, Taylor, Howse, Thomas, Ashby, Marshall, König, Wagner, Lange, Fenger, Bruglocher, and J. William White, of Philadelphia. Schneider reports a recovery after resection of five ribs and the clavicle, for empyema following gunshot injury.

The operation of resecting a rib is not particularly difficult, the chief points requiring attention being to avoid, if possible, wounding the pleura, and the intercostal artery and nerve. This is comparatively easy in cases of necrosis, in which the periosteum can commonly be separated from the bone and pushed backwards, but is less readily effected when the operation is employed for compound fracture, and is usually impracticable in cases of tumor, in which indeed the pleura is itself very apt to be involved. In the operation for empyema, the pleura is of course opened, and a portion cut away with the bone. When only a single rib is to be resected, a straight incision following its course will afford sufficient exposure, but when the operation is to involve more than one rib, it will be better to turn up a semilunar flap, as shown in Fig. 693. If the intercostal artery be divided, as it almost necessarily will be in cases of tumor or empyema, both ends should be immediately secured with ligatures. The rib itself may be severed with the chain-saw, or, in the case of a child, with strong cutting forceps.

Fig. 693.



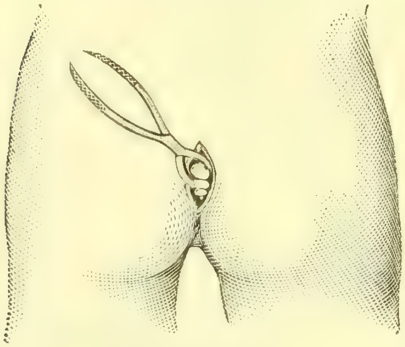
Resection of ribs.

Excisions of the Pelvis.—Portions of the *innominate bones* have been occasionally removed in cases of caries or necrosis, and the acetabulum not unfrequently requires gouging after removal of the head of the femur for hip-disease. But these operations should hardly be dignified by the name of excisions, any more than the extractions of separated fragments which may be required in cases of compound fracture from gunshot or other injury. Resection of the *pubic symphysis*, as a means of facilitating parturition, was suggested by Christophoris, some twenty-five years ago, and temporary resection of the same part was recommended by Pitois; two cases, however, in which the operation was practised by Galbiati, terminated fatally. Resection of the *descending ramus* of the pubis is recommended by O. Heyfelder in cases of fracture with compression of the urethra by a displaced fragment. The operation can be performed by placing the patient in the lithotomy position, and making a single incision in the line of the bone which is then divided with a chain-saw. Care must be taken not to wound the internal pudic artery, nor, if it can be avoided, the root of the corpus cavernosum. Trephining the *ilium* for the evacuation of psoas and pelvic abscesses has been practised by Fischer and Riedel.

Partial resections of the *sacrum* have been performed by several surgeons, including Prof. Volkmann, the late Dr. G. C. Blackman, and Prof. S. D. Gross. The operation has been practised in cases of fracture, of necrosis, and of tumor, malignant or otherwise. The bone may be exposed by means of a T-shaped or crucial incision, and the diseased part separated with a chisel or cutting forceps; great care should be taken not to injure the sacral nerves. Several instances of trephining or gouging the sacrum for the removal of balls in cases of gunshot fracture, are referred to in the article on Injuries of the Back.

Excision of the Coccyx.—Occasionally employed in cases of fracture or dislocation of the part, and at least twice for osteitis or caries (Von Onsenoort's and Ollier's cases), this operation is most frequently practised for the relief of a neuralgic condition described by Sir J. Y. Simpson, and known as *coccyodynia* or *coccygodynia*. The first excision of the coccyx for this cause appears to have been performed by the late Dr. Nott, formerly of Mobile, and afterwards of New York, and the operation is of so simple a nature, and usually gives such satisfactory results, that it has been frequently repeated by other surgeons. I have twice excised the coccyx for coccygodynia, and in both instances with the effect of giving entire relief from the pain which had been long continued, and, at times, agonizing. As after other operations for neuralgia, the benefit derived is sometimes only temporary; but as the operation is quite free from risk and involves no mutilation—consisting, indeed, in the removal of a mere useless appendage—it may be properly resorted to in any case in which it seems to be indicated.

Fig. 694.



Excision of the coccyx.

The bone is exposed by a single longitudinal incision, and after it has been freed from its muscular attachments, which can be conveniently done with the blunt-pointed resection knife, is cut away with strong forceps, as shown in Fig. 694. This plan is much easier than attempting to effect disarticulation, and is perfectly satisfactory. Dr. Garretson has removed the coccyx piece-meal, by drilling with the "dental engine."

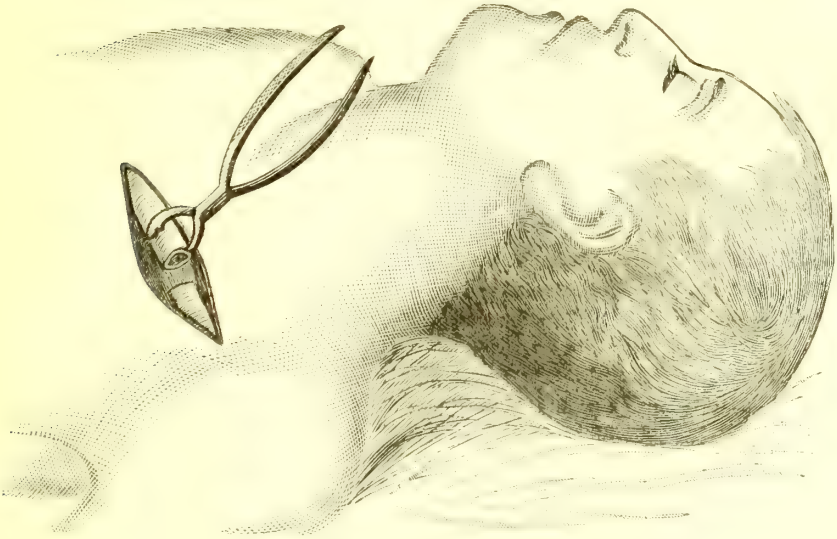
Excision of the coccyx has been recommended and practised by Verneuil as a means of obtaining more room in operations upon the lower part of the rectum.

EXCISIONS IN THE UPPER EXTREMITY.

EXCISION OF THE CLAVICLE.—The clavicle, in whole or in part, has been frequently excised in cases of caries or necrosis, of compound fracture, and of tumor. The inner end of the bone has also been removed by Davie, of Bungay, and other surgeons, on account of dislocation causing dangerous pressure on the trachea or œsophagus. An easy and usually a safe operation in cases of necrosis—in which, indeed, the procedure is often nothing more in reality than an extraction of sequestra—excision of the clavicle, in cases of tumor, is fraught with the greatest difficulty and danger; in Dr. Mott's famous case, the operation occupied nearly four hours, and the bleeding was so profuse that about forty ligatures were required. The first *complete extirpation* of the clavicle appears to have been performed by Dr. McCrearry, of Kentucky, in 1811, and the second by a German surgeon, Dr. Meyer, in 1823. Remmer's operation (in 1732), often spoken of as an extirpation, was really only a partial excision, and the same must be said of Dr. Mott's case, already referred to, for its published history[1] states distinctly that the acromial end of the bone was not interfered with, and the autopsy made by Dr. Porcher and Dr. Michel, after the patient's death, 54 years subsequently, showed that the portion left measured one and three-quarter inches.[2]

The operation can be best accomplished by making first a long incision in the line of the clavicle, extending, if necessary, from the acromial junction to the sterno-clavicular articulation of the *opposite* side, supplementing this wound, in cases of tumor, by one or more at right angles to it, as may be found desirable. If a healthy portion of bone can be exposed, an elevator or resection-sound may be slipped beneath it—if possible, between the bone and

Fig. 695.



Excision of the clavicle.

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[1] Am. Jour. Med. Sciences, O. S., vol. iii. p. 100.

[2] Ibid., N. S., vol. lxxxv. p. 146.

its periosteum—and the part then cautiously divided with a chain-saw. If the central portion of the clavicle only be involved, the chain-saw may be used on both sides, and the same instrument, or a small resection-saw, will be found convenient to sever the acromio-clavicular junction when the disease extends to that point. At the sternal end of the clavicle, disarticulation may be very cautiously effected with the knife. The bone is then drawn upwards with Fergusson's forceps, as shown in Fig. 695, and the parts below carefully separated by using as much as possible the handle of the knife instead of its blade. Great care must be exercised to avoid wounding the pleura, as well as the important arteries, veins, and nerves, which lie in proximity to the bone; any vessels that are divided should be immediately secured with ligatures.

Statistics of extirpation of the clavicle have been published by O. Heyfelder, by the late Dr. Otis, and by Prof. Agnew, the last-named author having tabulated 34 cases, several of which, however, should be rejected as only partial excisions, while two (Nélaton's and Richard's, and Gunn's cases) were extirpations *à deux temps*, several months having, in each instance, intervened between the removal of the outer, and that of the inner portion of the bone. The following table, which, for the sake of convenience in reference, I have arranged alphabetically, embraces only 28 cases, all of which, however, appear to have been actual extirpations of the bone at one sitting:—

Table of Total Excisions of the Clavicle.

No.	Operator.	Nature of case.	Result.	Reference.
1	Biangini,	Necrosis,	Recovered,	Gazette Médicale, p. 460. 1838.
2	Blackman,	Caries,	"	Western Lancet, vol. xvii. p. 336. 1856.
3	Bowe,	"	"	Med. Times and Gazette, vol. ii. p. 194. 1866.
4	Briggs,	Necrosis,	"	Nashville Journ. of Med. and Surgery, N. S., vol. xxi. p. 210. 1878.
5	Britton,	Cancer,	"	Brit. Med. Journal, vol. i. p. 518. 1870.
6	Carswell,	Caries,	"	Med. and Surg. Reporter, N. S., vol. xxxi. p. 299. 1874.
7	Cooley,	Osteo-sarcoma,	"	Richmond and Louisville Med. Journ., vol. viii. p. 620. 1869.
8	Curtis,	Malignant disease,	"	Am. Journ. Med. Sciences, N. S., vol. xxxiv. p. 350. 1857.
9	Dawson,	Necrosis,	"	Cincinnati Lancet and Observer, vol. xi. p. 1. 1868.
10	Esmarch,	Osteo-sarcoma,	"	Nissen, Dissertatio de Resectione. Kiliæ, 1859.
11	Eve,	Enchondroma,	Died,	Nashville Journ. of Med. and Surgery, N. S., vol. vii. p. 68. 1871.
12	Field surgeon,	Gunshot fracture,	"	Med. and Surg. Hist. of the War, First Surg. Vol. p. 557.
13	Heyfelder,	Necrosis,	"	Traité des Résections, trad. par Boeckel, p. 236. Paris, 1863.
14	Irvine,	"	Recovered,	Lancet, vol. i. p. 206. 1867.
15	Kunst,	Injury,	"	Deutsche Klinik, Bd. ii. S. 263. 1850.
16	McCrearry,	Necrosis,	"	Johnson, N. O. Med. and Surg. Journ., vol. vi. p. 474. 1850.
17	Mazzoni,	Osteitis,	"	Clin. Chirurg., t. iii. p. 120. Roma, 1876.
18	Meyer,	Caries,	"	Encycl. Wort. d. med. Wissenschaft., Bd. xxix. S. 96.
19	Morin,	Cancer,	"	Gaz. Méd. de Lyon, No. 8, p. 93. 1868.
20	Owens,	Osteo-sarcoma,	"	N. O. Med. and Surg. Journ., vol. xi. p. 164. 1854–5.
21	Palmer,	Gunshot fracture,	Died,	Tryon, Am. Journ. Med. Sciences, N. S., vol. xlix. p. 357. 1865.
22	Porquet,	Caries,	Recovered,	L'Année Médicale, t. ii. p. 84. Caen, 1877.
23	Roux,	"	Died,	Bull. Gén. de Thérap., t. vi. p. 246. 1834.
24	Travers,	Tumor,	Recovered,	Medico-Chirurgical Transactions, vol. xxi. p. 135.
25	Varick,	Necrosis,	"	N. Y. Med. Journ., vol. xxvii. p. 52. 1878.
26	Warren,	Osteo-sarcoma,	Died,	Surgical Observations on Tumors, p. 146. Boston, 1837.
27	Wedderburn	Caries,	Recovered,	N. O. Monthly Med. Register, vol. ii. p. 1. 1852.
28	Wutzer,	"	"	Orsbach, De resect. claviculæ. Bonnæ, 1833.

Of the whole 28 cases, only 6 proved fatal, a mortality of less than 22 per cent.

Partial excisions of the clavicle vary in severity from comparatively trifling affairs to such grave operations as those of Mott and Bartlett; Otis has collected 69 such cases, including those recorded during the War of the Rebellion; adding to these Mott's, Bartlett's, one of Wutzer's, Nélaton's, and Gunn's cases, incorrectly included by Dr. Otis among the cases of total excision, we have 74 cases, of which 59 recovered, and 10 died, the result in 5 being unknown; the mortality of determined cases, therefore, was but 14.5 per cent.

Excision of the Scapula.—This operation may be required in cases of caries or necrosis, in those of tumor, and in some cases of severe lacerated wound or compound fracture, though in these it is often necessary to remove the upper extremity at the same time, the operation then being an "amputation *above* the shoulder," as described in a previous portion of this Encyclopædia.[1]

The scapula may be removed by means of a crucial, an **H**-shaped, a **⅂**-shaped, or, which is commonly preferable, a **T**-shaped incision, as advised by the late Prof. Syme, of Edinburgh; the transverse branch of the wound extends from the acromio-clavicular junction, following the spine of the scapula, to the posterior edge of the bone, and the longitudinal branch, starting from the centre of the other, passes downwards as far as may be necessary. In traumatic cases, as in those of caries or necrosis, the muscles should be carefully separated from the bone, which should be removed with as little disturbance of the soft parts as practicable; in cases of tumor, however, the external incisions should be only skin-deep, as the muscles will probably be found to be infiltrated by the morbid growth, and blood may be saved by not cutting into the tumor, which may be very vascular. Hemorrhage during the operation is, indeed, one of the chief risks in excision of the scapula, and every means should be taken to avoid it. For this purpose an assistant should compress the subclavian artery with a padded key over the first rib, and, since there is apt to be very free bleeding from the superficial parts of the wound, it is well not to make the whole incision at first, but to begin with a cut of moderate size, and afterwards enlarge it when more room is found necessary. It is recommended by Sir W. Fergusson and Mr. Pollock to free the posterior border of the scapula first, and then the inferior, turning up the bone from below as the operation is continued. By doing this, the pulsation of the subscapular artery can be felt for, and the vessel controlled with the finger before it is divided. Prof. Spence, however, from practical experience with both methods, advises that the clavicular attachments should be first severed, so as to permit an assistant to control the subclavian artery by direct compression.

If the operation be performed for *malignant disease*, the whole scapula should be excised (Fig. 696), but, under other circumstances, it may be better to substitute partial excision; and there is certainly an advantage in retaining the neck of the bone and the glenoid cavity (not opening the joint), with the acromion and coracoid processes, when nothing can be gained by their removal. Under these circumstances, the bone is to be divided at the proper points with the saw or cutting forceps, and even in complete excision, it will commonly be found more expeditious to use the saw at the acromio-clavicular junction than to attempt disarticulation. The coracoid process also may be sawn through at any convenient point, and its tip afterwards dissected out when the removal of the tumor has been completed. In order to free the glenoid cavity, the joint should be opened, and the capsular ligament then carefully divided with the probe-pointed knife or with scissors.

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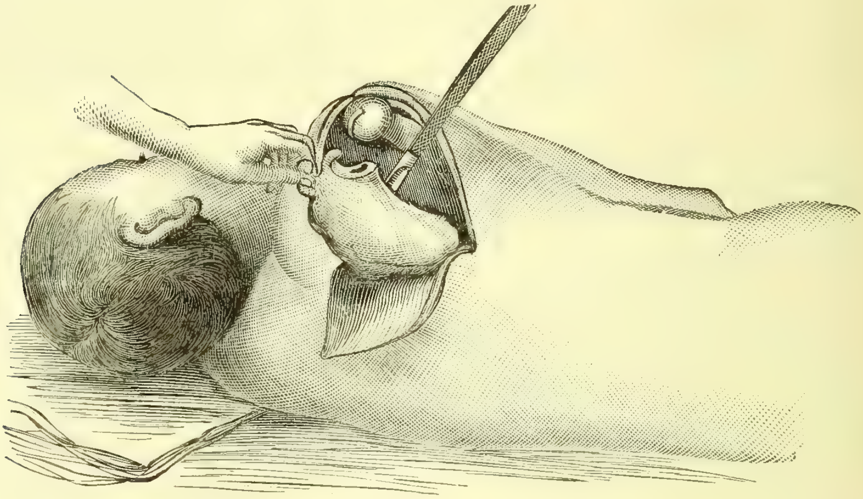
[1] See Vol. I. p. 647.

Fig. 696.



Excision of the scapula.

The mass having been removed, all bleeding vessels are to be secured, drainage tubes introduced, and the wound then closed with stitches. The arm may be placed upon a Stromeyer's cushion,[1] until the flaps have fairly united, and the arm afterwards simply supported in a sling.

It may sometimes be necessary to remove, with the scapula, a portion of the clavicle, the head and neck of the humerus, or both. These additions to the operation of course greatly increase its gravity, and the parts in question should not be interfered with, if such a course can possibly be avoided.

The *acromion process* or the *spine of the scapula* may readily be removed through a single transverse incision.

The history and statistics of excision of the scapula were made the subject of special investigation by the late Dr. Stephen Rogers, of New York,[2] and have been more recently studied by Prof. Adelmann, of Berlin,[3] who, however, has failed to make any distinction between excisions of the scapula proper, and operations in which the upper extremity has been removed at the same time, or amputations above the shoulder. The first case in which the entire scapula was extirpated, the arm being preserved, was that of Langenbeck, who, in 1855, thus removed the whole shoulder-blade with three inches of the clavicle. In the following tables I have arranged by the names of the operators, in alphabetical order, (1) 42 cases in which the whole scapula appears to have been excised, *the arm being preserved*, and (2) 14 cases in which total excision has been resorted to *subsequent to amputation at the shoulder*, but not at the same operation. The results in two cases of the first category have not been ascertained, leaving 40 determined cases with 32 recoveries and 8 deaths, a mortality of exactly 20 per cent. The 14 cases of the second category gave 11 recoveries and 3 deaths, a mortality of over 21 per cent. The results of complete are thus somewhat more successful than those of partial excision of the scapula, 206 recorded cases of which operation have given at least 49 deaths, a mortality of nearly 24 per cent.

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[1] See Vol. II. p. 158, Fig. 260.

[2] Am. Journ. Med. Sciences, October, 1868, and New York Med. Journal, December, 1870.

[3] Prag. Vierteljahrsschrift, Bd. 144, 1879.

Prof. Adelmann tabulates 195 cases as examples of partial excision, from which number 4 should be deducted as cases of amputation above the shoulder, and one as a case of total excision (King). To the remaining 190 are to be added 4 from Prof. Adelmann's table of complete excisions (Skey, Langenbeck, Fergusson, Sydney Jones), and 12 additional cases recorded by Péan, Zimmerman, Bœckel (two), Fischer (two), Nedopil, Berkeley Hill, Kurtz, Wolcott, Bellamy, and Ball, making a total of 206, as given above.

TABLE OF TOTAL EXCISIONS OF THE SCAPULA, THE ARM BEING PRESERVED.

No.	Operator.	Result.	Reference.
1	Agnew,	Died,	Record of Hospital of University of Pennsylvania.
2	Bellamy,	Undetermined,	Lancet, Oct. 9, 1880.
3	Billroth,	Recovered,	Archiv f. klin. Chirurgie, 1879.
4	Bird,	"	Lancet, 1865.
5	Brigham,	"	Boston Med. and Surg. Journal, June, 1878.
6	Busch,	"	Adelmann, Prag. Vierteljahrsschrift, Bd. 144.
7	Choppin,	Died,	N. O. Med. News and Hosp. Gazette, Jan. 1857.
8	Crawford,	Recovered,	Med. Times and Gazette, 1857.
9	Esmarch,	"	Arch. f. klin. Chirurgie, 1863.
10	Hamilton,	"	Med. and Surg. Reporter, 1866.
11	Hammer,	"	St. Louis Med. Reporter, 1866.
12	Heath,	Died,	British Med. Journal, 1879.
13	Heyfelder,	"	Deutsche Klinik, 1857.
14	Jones,	Recovered,	Medico-Chirurgical Transactions, vol. xlii.
15	King,	"	Liverpool and Manchester Reports, 1874.
16	Kottman,	"	Corr. f. d. Schw. Aertz., 1874.
17	Langenbeck,	"[1]	Deutsche Klinik, 1855.
18	Linhart,	"	Adelmann, loc. cit.
19	Logan,	"	Richmond and Louisville Med. Journal, 1872.
20	MacCormac,	"	Lancet, 1876.
21	Mazzoni,	"	Arch. di Chir. Prat., and Schmidt's Jahrb., Bd. 174.
22	Michaux,	"	Gazette Médicale de Paris, 1866.
23	Michel,	"	Gazette Hebd. de Méd. et de Chirurgie, 1874.
24	Nixon,	"	British Med. Journal, 1881.
25	O'Grady,	"	Dublin Journal of Med. Science, 1873.
26	Id.	"	British Med. Journal, Dec. 3, 1881.
27	Omboni,	"	Raccogl. Med., and Richm. and Louisv. Med. Journ., 1875.
28	Orlowski,	"	Centralblatt für Chirurgie, 1878.
29	Peters,	"	Am. Journ. Med. Sciences, 1878.
30	Pirrie,	"	Principles and Practice of Surgery, 1873.
31	Pollock,	Died,	St. George's Hospital Reports, 1869.
32	Rogers,	Recovered,	Am. Journ. Med. Sciences, 1868.
33	Schneider,	"	Berlin. klin. Wochenschrift, 1874.
34	Schuh,	"	Wien med. Wochenschrift, 1860.
35	Schuppert,	"	New Orleans Journ. of Medicine, 1870.
36	Spence,	"	Lectures on Surgery, 3d ed., vol. ii. p. 963.
37	Id.	Died,[2]	Ibid. p. 967.
38	Steele,	"	British Med. Journal, 1871.
39	Syme,	"	Excision of the Scapula, 1864.
40	Id.	Recovered,	Ibid.
41	Wood,	Undetermined,	Lancet, 1875.
42	....	Recovered,	Dublin Med. Press, Nov. 13, 1861.

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[1] Patient recovered from operation, but died from recurrence of disease.

[2] It is not mentioned in so many words, but the manner in which Prof. Spence speaks of this case renders it almost certain that it proved fatal.

TABLE OF TOTAL EXCISIONS OF THE SCAPULA AFTER PREVIOUS AMPUTATION AT THE SHOULDER-JOINT.

No.	Operator.	Result.	Reference.
1	Buck,	Recovered,	Rogers, Amer. Journ. Med. Sciences, October, 1868.
2	Busch,	"	Lehrb. d. top. Chirurgie, 1864.
3	Conklin,	"	Amer. Journ. Med. Sciences, January, 1883.
4	D'Ambrosio,	Died,	Movimento (Napoli), 1880, t. xii. p. 393.
5	Deroubaix,	Recovered,	Gazette Médicale de Paris, 1866.
6	Fergusson,	"	Medico-Chirurgical Transactions, vol. xxxi.
7	Jeaffreson,	"	Lancet, 1874.
8	Krakowizer,	Died,	New York Medical Journal, 1869.
9	Langenbeck,	Recovered,	Archiv f. klin. Chirurgie, Bd. iii.
10	Mussey,	"	Amer. Journ. Med. Sciences, 1837.
11	Rigaud,	"	Archives Gén. de Médecine, 1844.
12	Id.	"	Bull. de la Soc. de Chirurgie, 1875.
13	Soupart,[1]	Died,	Gazette Médicale de Paris, 1866.
14	Stimson,	Recovered,	Medical Record, Dec. 16, 1872.

EXCISION OF THE SHOULDER-JOINT.—Excision of the head of the humerus, or of the entire scapulo-humeral articulation, may be required in cases of destructive inflammation of the joint, caries or necrosis, compound fracture or dislocation, or non-malignant tumor. For cases of malignant growth, including sub-periosteal sarcomata, amputation is undoubtedly preferable, as permitting more thorough extirpation of the diseased structures; but in a case of enchondroma of moderate size, or in one of central sarcoma (if it could be recognized as such), I should be strongly tempted to substitute excision, which under these circumstances would probably be no more liable to be followed by recurrence than amputation, while it would of course have the advantage of giving a chance for the preservation of a fairly useful limb. The most frequent cause for excision of the shoulder is gunshot injury, and this operation is of all excisions in military surgery that which has upon the whole given the most favorable results. This point may be illustrated by the annexed table, borrowed from Gurlt, showing the "end-results" of the various joint incisions recorded during the Franco-German War.

TABLE SHOWING ULTIMATE RESULTS AFTER EXCISIONS OF THE LARGER JOINTS FOR GUNSHOT INJURY.

Seat of operation.	No. of cases.	Result of operation.					Per cent. of good results.	Per cent. of medium results.	Per cent. of bad results.
		Very good.	Good.	Medium	Bad.	Very bad.			
Shoulder . .	213	4	90	102	17	...	44.1	47.9	8.0
Elbow . . .	355	20	84	189	51	11	29.3	53.2	17.5
Wrist . . .	16	...	1	8	6	1	6.2	50.0	43.7
Hip . . .	4	1	3	...	...	...	100.0	......	......
Knee . . .	9	5	3	...	...	1	88.9	......	11.1
Ankle . . .	55	8	21	23	1	2	52.7	41.8	5.5
Aggregates	652	38	202	322	75	15	36.8	49.4	13.8

The shoulder-joint may be readily exposed by making either a rectangular, a V-shaped, or a U-shaped flap; or, which is amply sufficient under ordinary circumstances, a single, longitudinal incision, which is best placed, after the manner of Baudens and Langenbeck, somewhat on the anterior surface of the joint. (Fig. 697.) The knife is entered a little to the outer side of the coracoid process, and made to cut downwards and slightly outwards for about five inches, passing between the fibres of the deltoid muscle, and in the line of the bicipital groove. If this wound should not afford sufficient room, as may happen when the operation is practised in a case of tumor, it may readily be enlarged by adding a slight transverse incision at its upper end, either backwards over the acromion process, forwards over the clavicle, or in both directions, thus giving the wound the form of a **T**. Of the various

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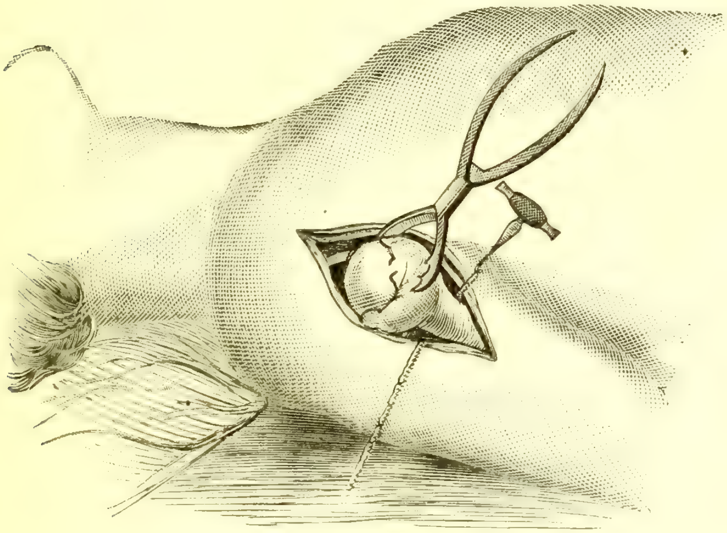
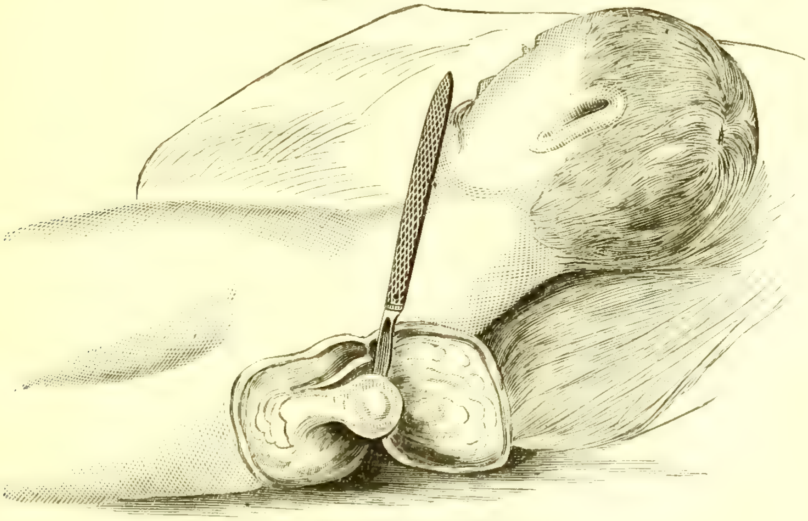
[1] The previous operation had been an amputation *above* the shoulder.

Fig. 697.



Excision of shoulder-joint by single longitudinal incision.

Fig. 698.



Excision of shoulder-joint by flap method.

flap-operations, the best is probably that with a semilunar or U-shaped incision, as advised by Morel and Bell (Fig. 698), but it makes an unnecessarily large wound, and the transverse division of the fibres of the deltoid muscle renders the arm less serviceable than it would be under other circumstances.

It is a matter of some importance, when it can be done, to preserve the integrity of the long head of the biceps muscle, and this can usually be accomplished by carefully opening the sheath, and having an assistant hold the tendon to one side with a blunt hook or a retractor. The capsular ligament is then to be divided, and the tuberosities of the humerus successively rotated into the wound, and cleared from their muscular attachments by using the probe-pointed knife. Finally, the head of the bone is made to project by pushing the elbow first backwards and then upwards, and its neck is then cut through with the chain-saw. If the glenoid cavity be diseased, it can next be attacked with the gouge or gouge-forceps; or, if too extensively involved to be thus dealt with successfully, may be exposed, by the aid of a transverse incision if necessary, and removed with the saw as directed in speaking of excisions of the scapula. Hemorrhage having been arrested, a drainage-tube is to be introduced, and the sides of the wound accurately approximated by means of the interrupted suture. An olive-oil dressing may then be applied, and the arm may be supported upon a Stromeyer's cushion until the wound has been fairly consolidated, after which a simple sling will afford sufficient support. The advantage in using Stromeyer's cushion instead of an ordinary axillary pad, is that, by keeping the elbow somewhat forward and away from the side, the contraction of the wound is encouraged, and the ligamentous bands by which repair is effected are shorter than they would be otherwise.

The first formal excision of the head of the humerus *for disease* appears to have been successfully performed by Bent, of Newcastle (England), in 1771,[1] while the first excision of the entire scapulo-humeral articulation was performed, likewise successfully, by the elder Moreau, in 1786. The first excision for *gunshot fracture* was that of Percy, in 1792, and the first American case of the same kind that of Dr. W. Ingalls, of Boston, which occurred in the winter of 1812–13.

The operation is a very successful one, considering its magnitude, the death-rate in military surgery, as shown by the table on page 444, having been but 35.4 per cent., while in civil practice the results have been still more favorable, 115 terminated cases of excision for disease, tabulated by Culbertson,[2] having given but 21 deaths, a mortality of only 18.2 per cent.; comparing these figures with those of shoulder-joint amputation,[3] which show a death-rate for all cases taken together of 37.7 per cent., it is obvious that, even as a means of saving life, excision, when admissible, is entitled to the preference.[4] The advantages of this operation are made still more apparent by the consideration that, in the successful cases in Dr. Culbertson's table, 63, or more than two-thirds of the patients are known to have had useful limbs, while the "end-result" of the procedure in military practice was, according to

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[1] The operations of Charles White (1768) and Vigaroux (1767), appear to have been excisions in the continuity of the humerus (see p. ‡3, note), while those of Schaeffenberg (1726), Thomas (1740), and Boucher (1745), were extractions of sequestra or fragments, and not formal excisions. A German surgeon, named Lentin, is said to have excised the head and greater part of the shaft of the humerus in 1771, the same year as that of Bent's operation.

[2] Prize Essay: Transactions Am. Med. Association, vol. xxvii., supplement. 1876.

[3] See Vol. I. p. 647.

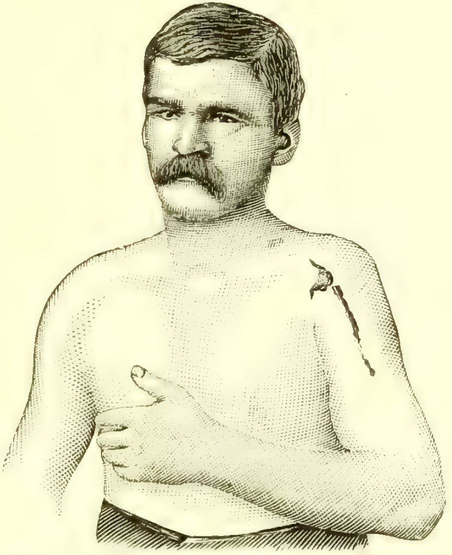
[4] The statistics of the War of the Rebellion, taken by themselves, show a less rate of mortality for shoulder-joint amputation, the death-rate of which operation, as given by Drs. Otis and Huntington, was 29.1 per cent., as compared with 36.6 per cent. for excision. (Op. cit., Third Surgical Volume, pp. 875–877.)

Dr. Gurlt's statistics, quoted on page 432, "good" in over 44 per cent., "medium" in nearly 48 per cent., and really "bad" in only 8 per cent. of cases ending in recovery.

As may be inferred from what has already been said, excision of the shoulder is not very often required in civil practice. My own experience in excision of the larger joints now extends to over sixty cases, but only once have I had occasion to resort to this particular operation.

The patient was a man, about 30 years of age, who was admitted to the University Hospital in June, 1882. He was suffering from disease of the left shoulder-joint, of considerable duration, and two sinuses were discharging very profusely, one on the front of the arm, and one above the clavicle. After watching the case for a few weeks, I thought it right to operate, in spite of the prevailing hot weather, because the sinuses showed no disposition to heal under expectant treatment, and because a tendency to hectic and the presence of the physical signs of incipient phthisis rendered it almost certain that the patient's strength would fail if we delayed further, in hope of obtaining a spontaneous cure. Accordingly, on July 6, the patient having been carefully etherized, I made a longitudinal incision in the manner above recommended, and having turned out the head of the bone, divided its neck with a chain-saw. One edge of the glenoid cavity, only, required gouging, and the limb was then dressed upon a Stromeyer's cushion, in the way already described. In spite of the formation of one or two abscesses the patient convalesced without any really unfavorable symptom, and rapidly gained flesh and strength as his wound healed. The annexed illustration (Fig. 699), from a photograph, shows the appearance of the part before the patient left the hospital; he reported himself again, some six months afterwards, in excellent condition, and with a very useful arm, though the "overhand" motions, as is often the case, were somewhat defective.

Fig. 699.



Result of shoulder-joint excision. (From a patient in the University Hospital.)

RESECTION OF THE SHAFT OF THE HUMERUS.—The shaft of the humerus may occasionally require resection in cases of *compound fracture*, especially from gunshot injury, though I must confess that my own experience leads me to think that in cases in which simple extraction of the splintered fragments is insufficient, amputation will usually prove the better remedy. I have, however, seen an excellent result from cutting off the projecting end of bone in a case of compound fracture with protrusion, in which reduction could not otherwise be accomplished. The operation may also be required in some cases of *caries* or *necrosis*, and Dr. Shrady, of New York, has recorded a most successful instance of sub-periosteal excision of almost the entire humerus for *acute necrosis*. But the condition in which resection of the humeral shaft has won its greatest triumphs, is that of *ununited fracture*, and when the operation is done in the manner recommended by Ollier, of Lyons, and by Bigelow, of Boston, it is quite a successful procedure.

A single longitudinal incision is made on the outer side of the arm, where the bone is comparatively superficial, going through one of the muscular interspaces, and taking care not to injure the musculo-spiral nerve, which, if exposed, should be carefully held out of the way with a retractor. The bone having been reached, the periosteum is divided and separated with the handle of the knife or with the elevator, and the ends of the fragments are then successively turned out and cut off with the chain-saw or small resection-saw, as may be found most convenient. Two fresh bone-surfaces having been thus obtained, the resected ends of the fragments are drilled, and a strong silver wire introduced and twisted to serve as a bone-suture. The external wound is then closed and lightly dressed, and the arm placed upon a bracketed or other convenient splint, so arranged that the dressings can be renewed without removing the whole apparatus. The wire which joins the fragments usually becomes loose in the course of five or six weeks, and may then be untwisted or cut, and gently withdrawn. When the external wound heals, the limb may be put up in a plaster-of-Paris bandage until osseous union is firmly established.

Dr. Macewen, of Glasgow, has reported a very interesting case in which reproduction of a humerus was effected by the transplantation of grafts of bone taken from other patients.

My individual experience in resection of the shaft of the humerus is limited to two cases: one of ununited fracture, with necrosis at the seat of injury, in which I operated in the manner above described with entire success; and one of severe gunshot fracture, in which, during the early days of the war, I adopted this operation in the case of a soldier of the 20th Massachusetts regiment, who had been wounded at the battle of Antietam. The case promised well for a week, when profuse secondary hemorrhage occurred, requiring amputation, from which the patient happily recovered. I also advised the operation in a case at the University Hospital, in which our house surgeon, Dr. R. H. Harte, successfully resected the protruding fragment in a case of otherwise irreducible compound fracture; and at the same hospital I directed the after-treatment of a case of ununited fracture successfully operated upon, in the manner described, by my colleague, Professor Agnew.

The statistics of excision in the shaft of the humerus, for gunshot fracture, are not very favorable, the mortality of all the cases recorded during the war of the Rebellion having been, according to Drs. Otis and Huntington,[1] 28.6 per cent., as compared with a mortality after amputation through the upper arm of only 23.8 per cent.[2] In many instances, the preserved arms appear to have been less useful than was at first anticipated. O. Heyfelder has tabulated 89 cases of this operation, for all causes, of which 17 ended in death and 16 more in failure; the unsuccessful results were therefore about three-eighths of the whole number.

Successful "total excisions" of the humerus have, according to Professor Gross, been recorded by Langenbeck, Billroth, and J. B. Cutter, of New Jersey.

TABLE SHOWING THE RESULTS OF EXCISION IN THE SHAFT OF THE HUMERUS FOR GUNSHOT INJURY.[3]

Period of operation.	Cases.	Recoveries.	Deaths.	Undetermined.	Mortality per cent.
Primary	487	326	145	16	30.7
Intermediate	93	64	29	...	31.1
Secondary	41	36	5	...	12.1
Unknown.	75	51	12	12	19.0
Aggregates	696	477	191	28	28.6

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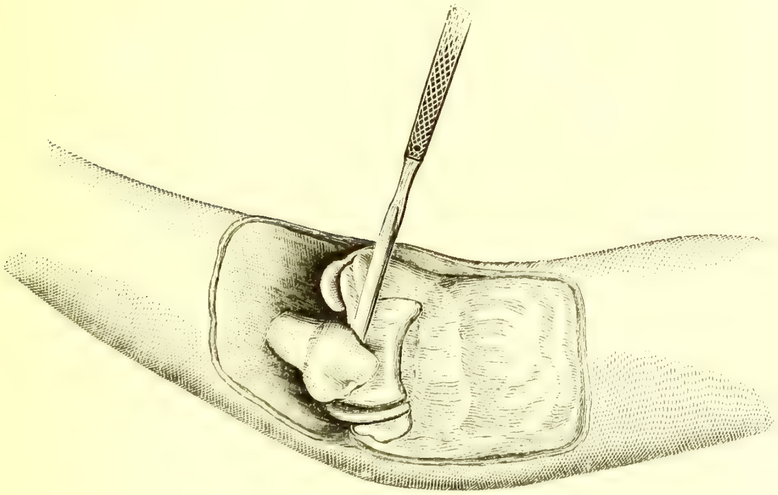
[1] Op. cit., Part Third, Surgical Volume, page 875. [2] Ibid., page 877. [3] Ibid., page 875.

Excision of the Elbow-Joint.—The elbow-joint may require excision on account of chronic disease involving the articulation (especially in cases of *strumous synovitis*, or, as I have preferred to call it, *gelatinous arthritis*), compound fracture or dislocation, or bony anchylosis. Even in cases of bony anchylosis with the limb in a good position, the operation may be properly resorted to in favorable cases, since the movable joint afforded by a successful excision is more useful than a stiff one.

The lower extremity of the humerus appears, as already mentioned, to have been resected by Wainman, of Shripton, England, in 1759, in a case of compound dislocation of the elbow; the operation was entirely successful, the patient surviving many years, and being able to "perform all the motions of the joint," which was "as flexible as if nothing had ever been amiss." This operation was repeated by Tyre, of Gloucester, likewise in a case of compound luxation, and with equal success, some twenty-five or thirty years afterwards; and about the same time, or a little earlier, Justamond successfully removed the olecranon and upper part of the ulna, in a case of caries.[1] But the first complete excision of the elbow-joint was performed by the elder Moreau, in 1794. The case was one of chronic joint-disease, and the patient recovered with a useful limb in the course of seven months. The first surgeon to introduce elbow-joint excision into military practice was the celebrated Percy, and the first case in American military surgery was that of Dr. Otis Hoyt, during the Mexican War, in 1847. The first American operation in civil practice was performed by Dr. John C. Warren, of Boston, in 1834.

Fig. 700.



Excision of elbow-joint by H-shaped incision.

Various incisions have been recommended for excision of the elbow, many surgeons, including Mr. Butcher, of Dublin, and the late Prof. Syme, of Edinburgh, preferring an H-shaped wound, as shown in Fig. 700, while others dispense with one of the longitudinal branches, thus reducing the incision to the form of a ├. The operation originally suggested by Park, however—a single longitudinal incision over the posterior, inner surface of the joint—affords abundant room in almost all cases, and has the advantage that the wound has no tendency to gape, and is thus better adapted for rapid healing. The incision begins (in an adult) about two inches above the olecranon, and extends three inches below it, the course of the wound being parallel to that of the ulnar nerve, and a few lines to its radial side. The only point requiring special caution in this operation is to avoid injuring the ulnar nerve, which should be carefully dissected from its position behind the internal condyle, the edge of the knife being kept close to the bone, and should then be held out of the way with a blunt hook or retractor. (Fig. 701.) In excisions for chronic disease, there is no difficulty in avoiding the nerve, which is surrounded by thickened and infiltrated tissue, and, indeed, need not be seen during the whole operation; but in cases of primary excision for injury, the nerve is not thus protected, and then must be guarded in the way already described.

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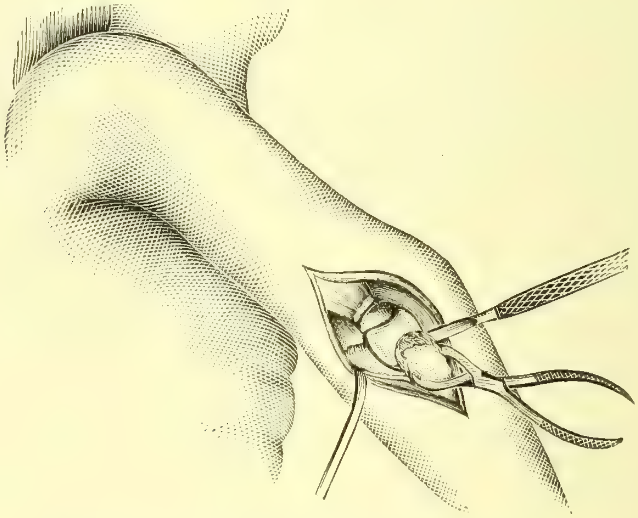
[1] In my "Principles and Practice of Surgery" (third edit. p. 627), I have, following Dr. Hodges, given the date of Justamond's case as 1775; but in Park's second letter, dated November 5, 1789, he speaks of this operation as having been performed since the publication of his first letter, which was in 1783.

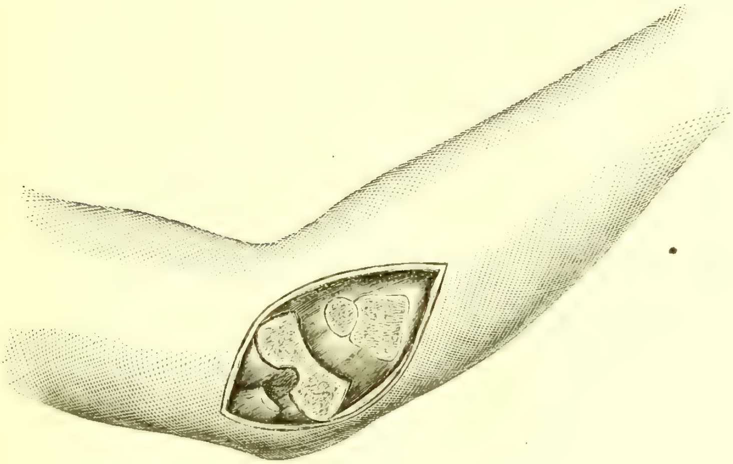
Fig. 701.



Excision of elbow-joint by single longitudinal incision.

The back of the articulation having been exposed, the olecranon process is to be cleared, and may then be severed with strong-cutting pliers; while not at all essential, this procedure will be found to greatly facilitate the remaining steps of the operation. Bruns, and more recently Trendelenberg and Völker, recommend temporary resection of the olecranon, which they subsequently restore to its position, keeping it in place with a wire suture. With the object of preserving, as far as possible, the function of the triceps muscle, Prof. Spence advised that its tendon should be divided by an inverted Λ-shaped incision, and for the same purpose Dr. Hodges and the late Mr. Maunder directed that those fibres should be left uncut which were inserted into the fascia of the forearm. Prof. Sayre only removes the tip of the olecranon, leaving that portion to which the tendon is attached. Whatever plan be adopted, the joint is next forcibly flexed, and the forearm thrust backwards, the lateral ligaments being then carefully divided with the probe-pointed knife. The operation is completed by removing the extremity of the humerus, just above the condyles, and the articulating ends of the radius and ulna, with Butcher's saw. The appearance of the wound after the bone-sections have been completed, is seen in Fig. 702. It is important, if possible, to retain the attachment of the biceps muscle, and therefore the tubercle of the radius should, unless itself diseased, be preserved, the bone being sawn through immediately below its head. Prof. Bigelow also preserves the external and internal condyles of the humerus, removing merely its articulating surface.

Fig. 702.



Excision of the elbow-joint; the operation completed.

The operation having been completed, all bleeding vessels are secured with ligatures, the wound closed with sutures (after the introduction of a drainage-tube), and then lightly dressed, and the limb placed either upon an Esmarch's bracketed splint,[1] or, which I have found to answer every purpose, an ordinary, internal, angular splint, well padded and secured with bandages, so arranged that the wound can be uncovered for inspection without disturbing the whole apparatus.

It is desirable to keep the ends of the bones pretty well approximated until the external wound has united, and therefore an obtuse-angled splint (about 135°) answers a better purpose than one which is rectangular. On the other hand, in order to avoid anchylosis—much more to be dreaded in these cases than the so-called "flail-like" union, which, indeed, from what I have personally seen of the operation I should be disposed to look upon as a myth—the splint should not be worn longer than is necessary for the wound to become fairly consolidated, and I have, in children, advantageously dispensed with it as early as the eighth day after the operation. When the splint is removed, the patient may carry the arm in a sling, during the day, and have it laid upon a soft pillow at night.

I do not know that I can further illustrate the subject of elbow-joint excision better than by appending abstracts of a few cases which have been under my own care. I have resorted to this procedure in ten cases (one of these a partial excision) with four deaths, but one, or at most two, of which, can, however, be fairly attributed to the operation. In the following case death was probably hastened by the excision, but I believe would have followed with equal certainty if no operation had been performed, and not improbably would have occurred at a still earlier period after amputation:—

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[1] See Vol. II. page 162, Fig. 263.

Arthritis of Left Elbow in an Elderly Man; Excision; Death from Exhaustion on Thirty-third Day.—This case occurred in a man, B. F., fifty-six years of age, a native of this country, and a blacksmith by occupation, who entered the surgical wards of the Episcopal Hospital on January 26, 1867. He had been sent into the medical wards the day before, under the impression that he was suffering from rheumatism, and the true nature of his affection was not ascertained until the visit of the attending physician, Dr. James H. Hutchinson, upon the next morning. When I first saw the patient his condition was as follows: There was great swelling about the left elbow, and the joint evidently contained a considerable amount of fluid. There was not much pain about the part, and no grating perceptible upon motion of the articulation. The patient's general state of health was fairly good, though he was feeble and looked much older than most men of his age. This was accounted for by the fact that for some years before entering the hospital he had led a life of much hardship, and it was hoped that under more favorable circumstances an opportunity would yet be afforded for recovery through the efforts of nature alone. For nearly six weeks there seemed to be some improvement, with occasional relapses, but at the end of that time it became evident that the ligamentous structures of the joint were becoming rapidly disorganized, and distinct grating on rubbing together the opposing joint surfaces showed that the articular cartilages were undergoing absorption, while the patient's constitutional condition began to deteriorate coincidently with the progress of the local disease.

When it became manifest that the elbow-joint was hopelessly disorganized, it became a question whether the limb should be sacrificed, or whether an effort should be made for its preservation by resorting to excision. The latter mode of treatment was adopted on account of the limitation of the diseased action to the joint itself, and because, in the unfavorable general condition of the patient, it did not appear that an amputation would be much less hazardous than an excision.

The patient was accordingly brought under the influence of ether on March 20, 1867, and, the joint being fairly exposed by an H-incision, an inch of the lower extremity of the humerus, and an inch and a quarter of the ulna, with the head of the radius, were removed by means of a Butcher's saw, and a considerable amount of disorganized tissue clipped away from the floor and sides of the wound with the large knife-bladed forceps described by the same eminent surgeon. A good many ligatures were required to arrest the hemorrhage from small vessels which had been enlarged by inflammatory action, and, the edges of the wound having been brought together with points of the lead suture, the limb was placed in a well-fitting fracture-box and the patient restored to his bed.

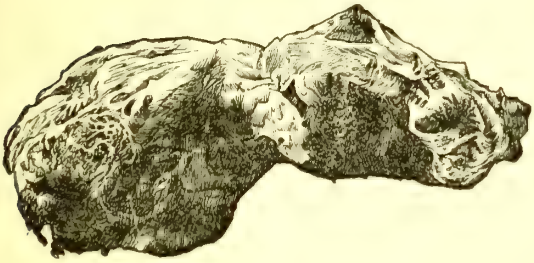
The relief from pain after the operation was most marked, and for a week or ten days the progress of the case was as favorable as could be wished; but from this time, though with occasional improvement, the patient gradually failed, and death, which occurred on April 22d, seemed due to exhaustion and general diminution of vital power rather than to any positive complication or sequel of the operation. Though the soft parts had united to a considerable extent, there was no attempt at union between the ends of the resected bones, and an autopsy showed that there was slight ulceration of the mucous lining of the bladder, possibly following the use of the catheter, which it had been necessary to employ frequently during the last period of the patient's life.

The next case was a more promising one for the operation, and doubtless would have terminated successfully but for the outbreak of tuberculous meningitis—an affection which, as every surgeon knows, is one of the causes of death which, in these chronic joint-affections, must always be taken into account in the matter of prognosis.

Excision of the Right Elbow-Joint for Disease in a Young Adult; Death from Tuberculous Meningitis.—This patient, J. D., a man twenty-five years of age, was admitted to the Episcopal Hospital on December 1, 1869, and first came under my care in January, 1870. The right elbow was the joint affected in this case, and the patient had been disabled by its condition for five or six months. The origin of the disease could not be ascertained, but the peculiar, globular shape of the part, the painless character of the swelling, and the degree to which passive motion could be carried, rendered it probable that the affection had begun in the synovial membrane and had thence spread to the ligamentous and cartilaginous structures, and that it was, in fact, an example of the condition described by Barwell as *strumous*, and by Athol Johnstone as *scrofulous synovitis*, and which I have myself ventured to call *gelatinous arthritis*.

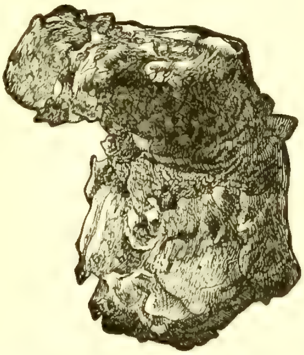
No benefit having resulted from careful treatment by rest and moderate extension in the hands of the gentleman who had had charge of the case before it came under my care, and being fully satisfied that the disease had progressed too far to admit of recovery without operative interference, I determined to resort to excision, and accordingly, on January 27, 1870, the patient having been placed under the influence of ether, I opened the joint by a single longitudinal incision on its inner and posterior side, and, turning out the bones, removed with Butcher's saw their articulating extremities, taking a mere shaving from the head of the radius, which was not diseased. I then clipped away the disorganized soft tissues, closed the wound with the lead suture, and placed the arm at rest on a well-padded internal angular splint.

Fig. 703.



Lower end of humerus removed by excision of elbow.

Fig. 704.



Upper end of ulna removed by excision of elbow.

The accompanying illustrations (Figs. 703 and 704) show the condition of the articulating surfaces of the humerus and ulna. The articular cartilage has disappeared from the radial head (capitellum) of the former, and from the greater sigmoid cavity of the latter bone, and at these spots the osseous tissue is seen to be exposed and carious.

For several months after the operation the patient's condition was satisfactory, and there appeared to be every prospect of the case terminating successfully; but, during the month of May, he underwent a severe attack of traumatic erysipelas, and shortly after convalescing from this affection became wildly delirious, with fever, intense headache, screaming, and the presence of a well-marked *tache cérébrale*, and died on June 7, nearly nineteen weeks after the operation. A *post-mortem* examination showed, as was expected, that the cause of death was tuberculous meningitis.

In the following case the operation gave the patient a very useful arm, though anchylosis occurred as regards flexion and extension. Had the patient been more persevering in exercising the limb, or had I ventured, as I have in more recent cases, to abandon the splint at an earlier period, the result would doubtless have been still more satisfactory:—

Suppurative Arthritis of Right Elbow resulting from Injury; Excision; Recovery.—Josephine K., aged seven years, was admitted to the Children's Hospital on October 16, 1870, suffering from arthritis of the right elbow, the result of an injury received some six months previously. The joint was painful and tender, hot, and swollen, particularly at its radial side. After a fair trial of the effect of rest, with the administration of tonics and the topical use of soothing applications, excision was resolved upon, and on December 19, 1870, the patient having been etherized, the operation was performed, the joint being laid open by a single longitudinal incision, and the articulating extremities of the several bones removed with the Butcher's saw. The joint was found to be full of pus, which gushed out as soon as the knife entered the articulation, the cartilages were eroded (especially over the head of the radius), and there was incipient caries of the subjacent bones. No ligatures were required, and, the edges of the wound having been brought together with leaden sutures, a strip of oiled lint was applied, and the limb placed at an angle of about 120° in a felt splint, which, however, bred maggots in the dressings, and was therefore replaced by a simple wooden splint on the third day. The after-progress of the patient was satisfactory; an abscess which formed in the neighborhood of the excision wound was opened on January 31, 1871; and in the following March the splint was left off, and a simple soap plaster and bandage substituted. The motions of pronation and supination were by this time fully restored, and there was slight power of flexion and extension, which could doubtless have been materially increased had the patient persevered in systematically exercising the limb. This, however, was not done, and anchylosis as regards flexion and extension eventually occurred. The patient was discharged from the hospital on April 15, 1872, but the last occasion upon which I saw her was in February, 1874, at which time the condition of the resected arm was very satisfactory, the limb though stiff being extremely useful, and the motions of pronation and supination being, as before remarked, perfectly restored.

The next case was also one of arthritis following injury, and, the splint having been dispensed with at an earlier period, the motions of flexion and extension were preserved, as well as those of pronation and supination.

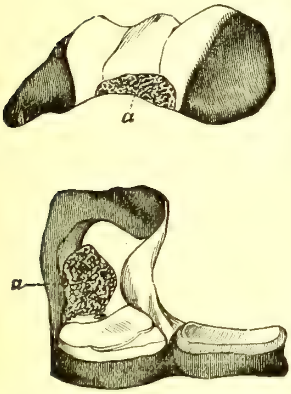
Excision of Left Elbow-Joint for Arthritis; Recovery.—The patient in this case was a boy, R. A., aged ten years, a native of Scotland, who was admitted to the Episcopal Hospital on January 11, 1872, suffering from arthritis of the left elbow, the result of an injury received one year previously. Excision was performed in the usual way, the joint being opened by a single incision made in the direction of the long axis of the limb, on January 18. Five ligatures were required, the excision wound was dressed with oiled lint, and the arm placed on an internal angular splint. The exsected parts presented a good example of ulceration of the articular cartilages with incipient disease of the underlying bone. The splint was left off in the course of a few weeks, and care taken to prevent the occurrence of anchylosis by the systematic use of passive motion. The result of the case was in every respect satisfactory, the patient leaving the hospital on June 1, 1872, with the wound firmly healed, and with the normal motions of the part quite restored.

In the next case I abandoned the use of the splint at a still earlier period:—

Excision of the Left Elbow-Joint in a Young Child; Splint left off after the Eighth Day; Recovery.—The subject of this case, G. P., a boy four years of age, entered the Children's Hospital on August 8, 1872, suffering from disease of the left elbow-joint of one year's duration, believed to have originated from an injury, though the history of this was not very clear. Excision was performed in the usual manner on August 12, two ligatures only being required, and the wound being closed with sutures, dressed with oiled lint, and placed on a splint; this, however, was dispensed with after the eighth day, by which time the wound had united and the parts were measurably consolidated, the limb from this time forward being simply supported in a broad sling. The condition of the exsected parts may be seen from the accompanying illustrations (Figs. 705, 706); the principal seats of disease were the base of the trochlea and the greater sigmoid cavity of the ulna, at which points (*a*, *a*) the cartilage had disappeared and the subjacent bone was carious and deeply eroded. The progress of the case after the operation was satisfactory; an abscess which had formed in the neighborhood of the joint was opened on February 28, 1873, and the patient left the hospital on May 28, of the same year. A photograph, from which the annexed illustration (Fig. 707) has been copied, was taken in October, 1873, at which time the wound was firmly healed, the arm strong, and the motions of the part perfect in every respect.

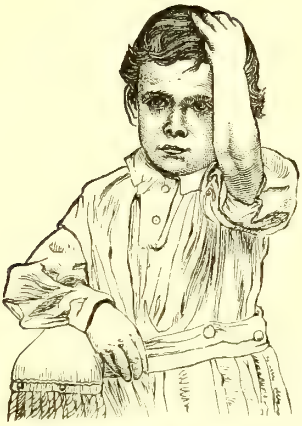
In the next case the patient made a good recovery as far as the operation was concerned, but perished from the effects of constitutional disease nearly seventeen months subsequently.

Figs. 705, 706.



Parts removed in excision of the elbow.

Fig. 707.



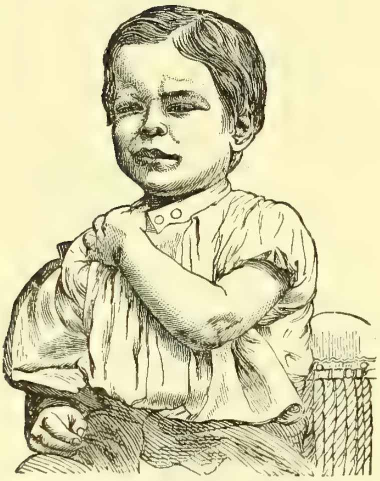
Result of excision of elbow-joint.
(From a patient in the Children's Hospital.)

Excision of the Right Elbow-Joint for Destructive Disease, the Result of Hereditary Syphilis; Recovery; Death from Syphilitic Disease of the Brain, nearly a year and a half afterwards.—The patient in this case was one of those unfortunate children of whom we see so many in surgical practice among the poor of large cities, who enter upon life bearing about them the seeds of death, and who after a few years of suffering perish miserably, the victims of their parents' misconduct. J. S., a boy six years of age, entered the Children's Hospital on September 4, 1872, suffering from hereditary syphilis in an aggravated form. The record at the time of his admission shows that he had then necrosis of the left radius, and of the lower jaw, with severe osteitis of the right humerus, extending to the lower epiphysis of the bone and threatening the integrity of the elbow-joint. A day or two after admission, a superficial exfoliation was removed from the radius, and on September 9, the patient being etherized, a large sequestrum was taken from the jaw, the portion removed extending to the articulation of the left side, and constituting about one-third of the lower maxilla. Under careful nursing and constitutional treatment, the patient's general condition now improved, and the jaw and left arm healed; the state of the right arm, however, became steadily worse, and in January, 1873, it became evident that the elbow-joint was hopelessly diseased. Excision was accordingly resorted to on January 13, the operation being performed in the usual way, the wound dressed with oiled lint, and the limb laid upon a splint, which, however, was dispensed with as soon as the parts had become sufficiently consolidated. The progress of the case, as far as the operation was concerned, was satisfactory, the wound healing well and the patient regaining considerable use of the limb; but fresh evidences of constitutional syphilis were not slow to manifest themselves. Gummatous tumors, which rapidly ulcerated, formed on the arm, on the shoulder, and on the side of the chest; the *upper* jaw became necrosed, and in October about one-third of its alveolar border was removed; finally, in June, 1874, symptoms of cerebral disease were developed, the patient lying in a stupor unless roused, when he was delirious, but without excitement; and in spite of the administration of large doses of iodide of potassium, death preceded by coma took place on June 7. No *post-mortem* examination was permitted, but there can be little doubt that intra-cranial syphilis was the cause of the fatal issue.

The next case is illustrative of a condition perhaps more often met with in the knee than in the elbow, but which, when occurring in either situation, may, in children at least, be treated by excision with the most gratifying results.

Excision of the Left Elbow Joint for Partial Anchylosis with Recurrent Arthritis; Recovery.—This case occurred in a German boy, C. K., six years old, who was admitted to the Episcopal Hospital on March 24, 1873. A year before, the left elbow had received an injury, the nature of which was unknown, and for which no treatment had been employed. The joint at the time of the patient's admission was partially anchylosed, tender and painful on motion, with considerable thickening of the soft parts, and a distortion which simulated partial displacement of the radius. The part was constantly getting hurt, and every fresh injury left the limb more crippled than before. Excision was performed in the usual way on March 27, the lower epiphysis of the humerus being found to be separated, and slightly carious, and the soft tissues of the joint presenting in parts the characteristic changes of gelatinous arthritis. The after-progress of the case was perfectly satisfactory; all the sutures were removed on April 1 (no ligature had been required); on April 18, the patient was allowed to get up; by May 17, the wound was almost healed, and the functions of the part in a great measure restored; and finally, on November 13, the patient was discharged from the hospital cured, the photograph from which the annexed illustration (Fig. 708) is taken having been secured a few days before his departure.

Fig. 708.



Result of excision of elbow-joint.
(From a patient in the Episcopal Hospital.)

In addition to the seven cases of which I have given the above brief abstracts, I have twice excised the elbow, in adults, for severe compound fracture into the joint, and once (a partial excision, involving only the olecranon and upper part of the ulna) for syphilitic necrosis (hereditary) in a child: this case ended favorably, the boy acquiring good motion in the joint, but both the traumatic cases were followed by death—in one from delirium tremens, and in the other from traumatic gangrene. The following table summarizes in a compendious manner the facts of the whole ten cases referred to.

Table of Ten Cases of Excision of the Elbow.

No.	Sex and age.	Nature of affection for which operation was required.	Result; duration of treatment after operation.	Remarks.
1	Male, 56	Arthritis of left elbow	Died; 33 days	Death from exhaustion.
2	Male, 25	Gelatinous arthritis of right elbow	Died; 19 w'ks	Death from tuberculous meningitis.
3	Female, 7	Arthritis of right elbow from injury	Recovered; 16 months	Anchylosis as to flexion and extension.
4	Male, 51	Compound fracture and dislocation of right elbow	Died; 7 days	Death from delirium tremens.
5	Male, 10	Arthritis of left elbow from injury	Recovered; 4½ months	Normal motions of part restored.
6	Male, 4	Arthritis of left elbow	Recovered; 9½ months	Normal motions restored.
7	Male, 6	Right elbow destroyed by hereditary syphilis	Recovered from operation	Utility of limb fairly restored; death from syphilitic disease of brain nearly a year and a half subsequently.
8	Male, 6	Partial fibrous anchylosis of left elbow, with recurrent arthritis	Recovered; 7½ months	Normal motions of part restored.
9	Male, 38	Railroad crush of elbow	Died; 5 days	Death from traumatic gangrene.
10	Male, 10	Necrosis of ulna from hereditary syphilis	Recovered; 10 weeks	Normal motions preserved. (Partial excision.)

The circumstances which most influence the *results* of elbow-joint excision, are the age and constitutional condition of the patient, and the nature of the affection for which the operation is performed.

To show the effect exercised by the patient's *age*, I have compiled the following table from the figures given by Dr. Culbertson,[1] which, although the number of cases in which the age was not ascertained is too large to allow any very positive statements to be predicated upon them, yet illustrate the fact, familiar to practical surgeons, that, as in the case of most of the other joints, the most favorable age for excision is that of childhood and early youth, and that after the period of puberty the mortality steadily increases with advancing years.

TABLE SHOWING RESULTS OF EXCISION OF THE ELBOW AT DIFFERENT AGES.

Age.	Total.	Recovered.	Died.	Result undetermined.	Mortality per cent. of terminated cases.
Under 5 years	12	10	2	...	16.7
Between 5 and 10 years	29	24	3	2	11.1
" 10 " 15 "	55	50	4	1	7.4
" 15 " 20 "	69	59	6	4	9.2
" 20 " 25 "	85	71	11	3	13.4
" 25 " 30 "	58	47	10	1	17.5
" 30 " 40 "	62	49	11	2	18.3
Over 40 years	49	36	11	2	23.4
Age not stated	656	535	106	15	16.5
Aggregates . . .	1075	881	164	30	15.7

The *constitutional condition* of the patient exercises a very important influence on the result of the operation. There is no doubt less immediate risk attending an excision of the elbow than an amputation of the arm, on account of the comparative freedom from hemorrhage in the case of the first-named operation; but the much longer period required for convalescence, after excision, not only exposes the patient necessarily during a longer time to the inroads of what are often, though improperly, called hospital diseases (erysipelas, pyæmia, etc.), but gives opportunity for the development of visceral diseases, especially tuberculous and amyloid degeneration, or for their aggravation if already in existence.

Hence, before determining to resort to excision of the elbow, particularly in the case of an adult, the surgeon should carefully inquire into the patient's constitutional condition, and especially into the state of the lungs, liver, and kidneys; should there be reason to suspect serious disease of any of these organs, the operation of excision would be so far contra-indicated, and, if under these circumstances any interference should be required, preference should as a rule be given to amputation.

The influence exercised upon the result of elbow-joint excision by the *nature of the affection* for which the operation is required, is clearly shown by the following table, compiled from Dr. Culbertson's[2] figures, supplemented by those of Prof. Gurlt,[3] in respect to gunshot injuries:—

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[1] Op. cit., p. 482.

[2] Op. cit., p. 488.

[3] See Table on page 444.

TABLE SHOWING RESULTS OF EXCISION OF THE ELBOW FOR INJURY AND FOR DISEASE OR DEFORMITY.

Nature of case.	Total.	Recovered.	Died.	Result undetermined.	Mortality per cent. of terminated cases.
Gunshot wound	1309	987	322	...	24.6
Other injury	70	56	10	4	15.1
Disease or deformity . . .	407	346	41	20	10.6
Aggregates . . .	1786	1389	373	24	21.2

There still remain to be considered the comparative advantages of *partial* and of *complete excision*, and the value of the preserved limb or the *end-result* of the operation.

Partial excision (in military surgery) is preferred by Dominik, and his view is favored by Hueter, Langenbeck, and Gurlt, but, as far as the statistics of the late American war are concerned, the advantage is with the more sweeping operation. I am disposed, however, to acquiesce in the justice of Dr. Otis's suggestion, that in traumatic cases, and, I may add, in some cases of necrosis—provided that the joint be fully exposed and free drainage secured—it may be sufficient to cut away the parts actually injured or diseased. In anchylosis, also, it may suffice to excise merely the lower part of the humerus, as advised by P. H. Watson and Annandale. But in all cases of chronic disease of the articulation, and certainly in most cases of gunshot injury, *complete excision* may be expected to give the best results. The following table, compiled from the statistics collected by Dr. Otis[1] and Dr. Culbertson,[2] gives the figures bearing upon this subject:—

TABLE SHOWING RESULTS OF PARTIAL AND OF COMPLETE EXCISION OF THE ELBOW.

Nature of case.	Partial.			Complete.			Not Stated.			Total.		
	Recovered.	Died.	Mortal. per ct.	Recovered.	Died.	Mortal. per ct.	Recovered.	Died.	Mortal. per ct.	Recovered.	Died.	Mortal. per ct.
Gunshot wound	294	84	22.2	93	21	18.4	83	41	33.1	470	146	23.7
Other injury . .	25	2	7.4	30	8	21.1	1	...	......	56	10	15.1
Dis. or deformity	45	5	10.0	295	32	9.8	6	4	40.0	346	41	10.6
Aggregates .	364	91	20.0	418	61	12.7	90	45	33.3	872	197	18.4

The *utility of the preserved limb*, after excision of the elbow, is in most cases very great. As already mentioned, there is much more risk of anchylosis than of excessive mobility, and this is one reason for preferring, in most cases, complete to partial excision. Indeed, it may be said that, within reasonable limits, the more bone that is removed, the better is the result likely to prove. Prof. Ollier lays great stress upon the importance of preserving the periosteum in elbow-joint excisions, with a view of obtaining reproduction of the articular extremities, and consequent restoration of function; but in many cases operated upon in the ordinary way, the limb becomes in the course of time so useful as to leave nothing to be desired in this respect. Ollier reports 36 cases operated on by the sub-periosteal method, with only 5 deaths; and in a later communication[3] brings up the number to 48 cases, with not a single death due to the operation itself. The "end-results" of the operation in military practice, as shown by the table on page 470 from Gurlt, are upon the whole satisfactory, the proportion of good results being nearly one in three, of medium results more than one in two, and of really bad results only about one in six. In civil surgery, the results are even more gratifying, Dr. Hodges's tables showing that 77 out of 89 patients who recovered, had useful limbs, and those of Drs. Heyfelder and Bœckel, giving the figures as 94 out of 118.

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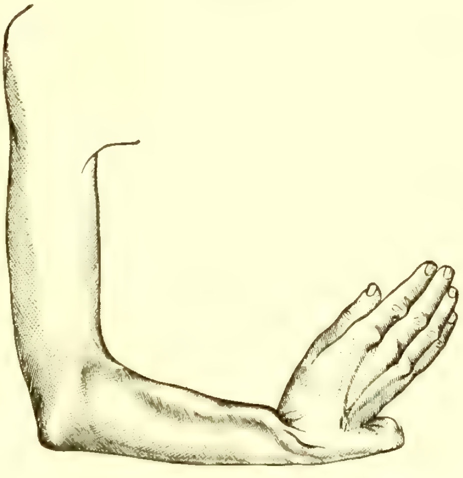
[1] Op. cit., Second Surgical Volume, p. 894.

[2] Op. cit., p. 492.

[3] Des Résections et des Amputations chez les Tuberculeux, p. 7. Paris, 1883.

Excisions of the Radius and Ulna.—Excision of the bones of the forearm, one or both, partial or complete, may be required in cases of caries or necrosis, certain forms of tumor, and compound or ununited fracture. Of the more extensive operations of this kind, the earliest of which I have any knowledge was that of Dr. R. B. Butt, of Virginia, who, in 1825, resected the lower two-thirds of the ulna on account of caries, the patient recovering with a useful limb. A similar operation, involving the removal of almost the whole radius, in a case of necrosis, was performed at the Pennsylvania Hospital by Dr. J. Rhea Barton, of Philadelphia, in 1828. This case appears never to have been published until a few months ago, when Dr. W. Barton Hopkins, a kinsman of the distinguished operator, came across the patient in the out-door service of the Episcopal Hospital, and subsequently exhibited her at a meeting of the Philadelphia College of Physicians.[1] Dr. Hopkins had an engraving made to show the appearance of the limb, and has kindly given me an electrotype of the same. (Fig. 709.) In spite of the marked deformity in this case, the patient had regained almost perfect use of her arm.

Fig. 709.



Deformity following excision of the radius.

Still more extensive excisions in this locality have been done by Compton, of New Orleans, who, in 1853, removed the whole ulna and greater part of the radius; by Williamson, who excised the entire ulna and the elbow-joint; and by Erichsen, who excised the elbow-joint with the greater part of the radius. Complete excision of the ulna has been practised by Carnochan, of New York; Jones, of Jersey; Joseph Bell, of Edinburgh; Hutchison, of Brooklyn; and W. M. Fuqua, of Hopkinsville; while complete excision of the radius has also been resorted to by Carnochan, and by C. C. Field, of Easton, Pa.

The operation, in the case of the radius, requires a longitudinal incision of sufficient length, on the outer and posterior aspect of the forearm, the bone being then bisected with the chain-saw, and either portion dissected out separately (Fig. 710). In cases of necrosis, an attempt should be made to preserve the periosteum. For excision of the ulna, a similar operation is required, but the wound is, of course made on the inner instead of the outer side of the limb.

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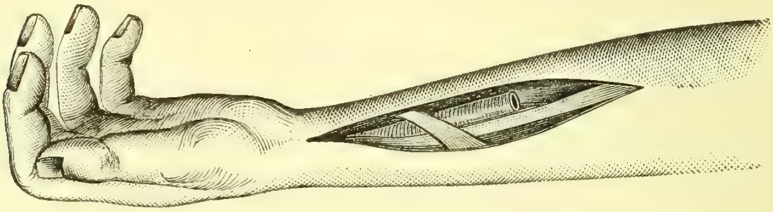
[1] Trans. Coll. Phys. Phila., 3d S. vol. vi. p. 371.

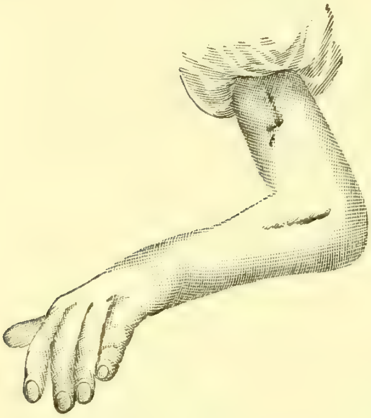
My personal experience of these operations is limited to partial excisions, twice of considerable portions of the radius, in cases of gunshot fracture (one a primary and one a secondary operation), and once of the same bone in a case of ununited fracture, in which, after resecting the bone, I secured the fragments together with wire sutures, after the manner of Prof. Ollier and Prof. Bigelow. All of these operations were successful, though in both the cases of gunshot fracture the patients went through sharp attacks of pyæmia before recovering. The appearance of the limb in the case of primary resection is shown in the accompanying illustration. (Fig. 711.)

Fig. 710.



Excision of the radius.

Fig. 711.



Result of partial excision of the radius. (From a patient in the Episcopal Hospital.)

The results in these cases are usually quite satisfactory as regards the life of the patient, and even as regards utility of the preserved limb, though if any considerable portion be removed from either bone alone, there is apt to be marked deformity with deflection of the hand toward the affected side. Even in cases of myeloid tumor of the bones, which are usually considered to require amputation, success, as has already been mentioned, has followed excision in the hands of Mr. Lucas and Mr. Morris. The following table, compiled from the statistics furnished by Drs Otis and Huntington,[1] shows that the mortality of the operation in military practice is very small—considerably less than that which attends amputation of the forearm; so that in favorable cases, and particularly when one bone only is involved, and when the laceration of the soft parts is not extensive, the operation may be properly resorted to. Heyfelder tabulates 39 cases, derived mainly from the records of civil life, without a single death, and with 34 more or less perfect successes as regards the restoration of function.

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[1] Op. cit., Third Surgical Volume, page 875.

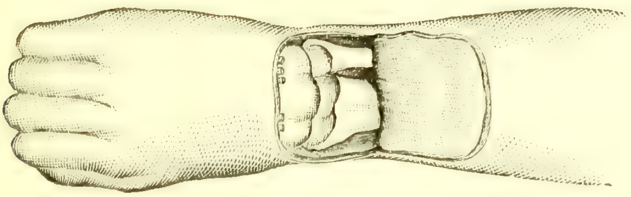
TABLE SHOWING RESULTS OF EXCISIONS IN SHAFTS OF RADIUS AND ULNA FOR GUNSHOT INJURY.

Period of operation.	Total.	Recovered.	Died.	Undetermined.	Mortality per cent.
Primary	665	589	71	5	10.7
Intermediate	149	120	29	...	19.4
Secondary	40	36	4	...	10.0
Unknown	132	111	5	16	4.3
Aggregates	986	856	109	21	11.3

EXCISION OF THE WRIST-JOINT.—Judging from my own experience, I should say that wrist-joint excision was an operation the indications for which were seldom met with; at least, I have never seen a case in my own practice in which I have felt it right to resort to this operation, those cases, whether of injury or of disease of the wrist, which have been bad enough to require any operation, having been so bad as to make me think amputation a safer remedy. The fact is, that there is no joint in the body in which more can be done by careful and long-continued, expectant treatment than in the wrist; the part can be kept quite at rest on a splint, while the patient goes about and pursues his ordinary avocations, and unless some complication, such as grave visceral disease, intervenes to prejudice the prospects of recovery, an ultimate cure can almost certainly be prognosticated. I have more than once seen wrists in which the carpal bones seemed to be completely separated from each other, rattling about like beans in a bag, and in which, nevertheless, recovery with a useful hand was eventually obtained. At the same time, I doubt not that cases do occur in which operative interference is imperative, and in which excision should be preferred to amputation.

The lower end of the radius was successfully excised by Cooper, of Bungay, in 1758, but the first operation which deserves to be termed an excision of the wrist-joint appears to have been performed by the elder Moreau, in 1794. Various forms of operation have been adopted for wrist-joint excision, those which afford the most complete exposure of the articulation being probably the **H**-shaped incision, and the dorsal flap method of Velpeau, shown in Fig. 712. No large vessels are cut by this incision, but even if the extensor tendons of the fingers are not divided, as they usually must be, they will necessarily be more or less bruised and lacerated, and will be so matted together by the subsequent inflammation that the utility of the hand will be considerably impaired. Hence, by the general consent of surgeons, the modification of Dubled's operation introduced by Prof. Lister, is now preferred to any other.

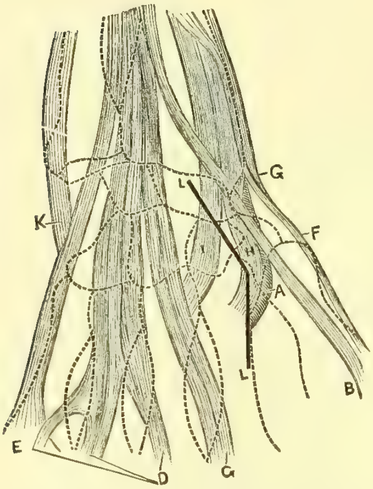
Fig. 712.



Excision of wrist by flap method.

This procedure, the advantages of which can be best understood by a reference to the annexed diagram (Fig. 713), requires two incisions, one on the radial and one on the ulnar side of the joint. The *radial incision* begins about the middle of the dorsal aspect of the radius, on a level with the styloid process, and extends downwards and outwards toward the inner side of the metacarpo-phalangeal articulation of the thumb, but, on reaching the line of the radial border of the metacarpal bone of the index finger, diverges at an obtuse angle and passes longitudinally downwards for half the length of that bone. The *ulnar incision* begins two inches above the end of the ulna, and immediately in front of it, extends downwards between the ulna and the flexor carpi ulnaris, and ends at the middle of the palmar aspect of the fifth metacarpal. The only tendons necessarily severed in this operation are the extensors of the carpus itself. The trapezium is to be separated from the other carpal bones by cutting with the bone-forceps before the ulnar incision is made, but is not to be removed until a later stage of the operation; in like manner, the pisiform bone is to be separated and left attached to the flexor carpi ulnaris, while the hook of the unciform bone is also cut through and left attached to the annular ligament. The tendons are next raised both in front of and behind the wrist, when the anterior ligaments of the joint are divided, and the cutting pliers then introduced, first between the carpus and radius, and afterwards between the carpus and metacarpus. Its connections having been thus severed, the entire carpus, with the exception of the trapezium and pisiform bones, can be pulled out with a strong pair of forceps. The articulating extremities of the radius and ulna are next made to protrude through the ulnar incision, and as much sawn off as may seem necessary; the ulna should be sawn obliquely so as to leave the styloid process, the retention of which serves to diminish the tendency to subsequent displacement. The articulating ends of the metacarpal bones are next brought out and resected, and the operation is then finished by carefully dissecting out the trapezium, and by removing the articulating surface of the thumb, and as much of the pisiform and hook-like process of the unciform as may be thought desirable. Free drainage must be secured by leaving the ulnar wound partly open, or by the introduction of drainage-tubes, and the hand may then be placed upon such a splint as is shown in Fig. 633 (page 286), or, which would probably answer as well, an ordinary Bond's splint. (Fig. 613, page 175.)

Fig. 713.



Excision of wrist by Lister's method.—A. Radial artery. B. Tendon of extensor secundi internodii pollicis. C. Indicator. D. Extensor communis digitorum. E. Extensor minimi digiti. F. Extensor primi internodii pollicis. G. Extensor ossis metacarpi pollicis. H. Extensor carpi radialis longior. I. Extensor carpi radialis brevior. K. Extensor carpi ulnaris. L L. Line of radial incision. (After Lister.)

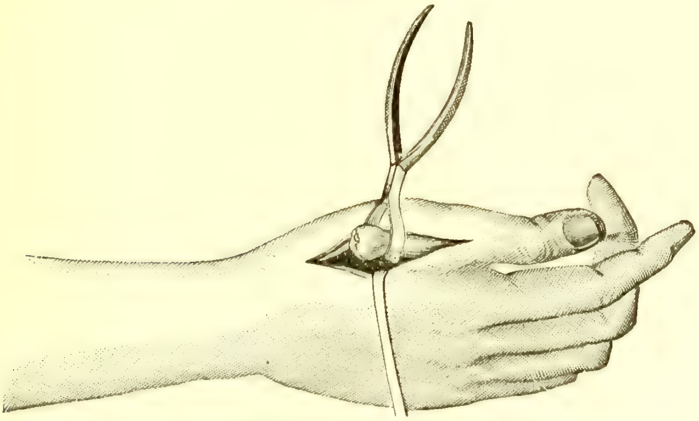
Mr. Butcher, and more recently Mr. W. R. Williams, have urged very strongly that the trapezium should be preserved in this operation, believing that the future utility of the thumb depends greatly upon its retention; the last-named surgeon has found, as did Sir W. Fergusson, that it is feasible to remove the carpus through a single longitudinal incision, on the ulnar side.

Partial excisions of the carpus have been practised, but, I think, have not usually proved very satisfactory; in a good many instances, destructive inflammation has spread to other parts of the wrist, necessitating amputation, and when this has not occurred anchylosis has commonly followed, impairing of course the usefulness of the limb.

The *statistics* of wrist-joint excision are quite favorable as regards the life of the patient: of 119 cases in military surgery analyzed by Prof. Gurlt,[1] only 19 proved fatal, a mortality of less than 16 per cent., while 85 terminated cases of excision for disease, tabulated by Dr. Culbertson,[2] gave but 10 deaths, a mortality of less than 12 per cent. Sixteen cases of excision for injury other than gunshot wound, collected by the same author, gave only two deaths, a mortality of 12.5 per cent. On the other hand, subsequent amputation was required in 10 cases of excision for disease, in Dr. Culbertson's tables; in 11 the preserved hand was "not useful;" and in 16 more the result as regards utility was uncertain—thus reducing the number of certainly successful operations to 42, or less than one half. Gurlt's figures also, as given in the table on page 432, show that after operations for gunshot injury the preserved limb has usually been anything but satisfactory, the cases therein recorded having given seven "bad" results, eight "medium" results, and only one "good" result among the whole sixteen. Hence, while the operation may be properly resorted to in selected cases—and particularly in favorable cases of compound fracture and dislocation in civil life—it cannot be said that the wrist is a locality in which the advantages of excision are conspicuous.

Excisions in the Hand.—The *metacarpal bones* may require excision on account of gunshot fracture, tumor, or necrosis. Compound fractures resulting from injuries other than gunshot wounds, usually, if any operation is demanded, require amputation. A single longitudinal incision on the back of the hand suffices to expose one of the metacarpals; precautions must be taken not to injure the extensor tendon, which should be carefully held to one side. If a partial excision is to be practised, the bone may be divided with cutting pliers, but for a complete excision, disarticulation from the phalanx should be first effected, and the bone then held up with Fergusson's forceps while it is separated from its palmar and carpal attachments. In cases of necrosis, an effort should be made to preserve the periosteum. When

Fig. 714.



Excision of metacarpal bone of thumb.

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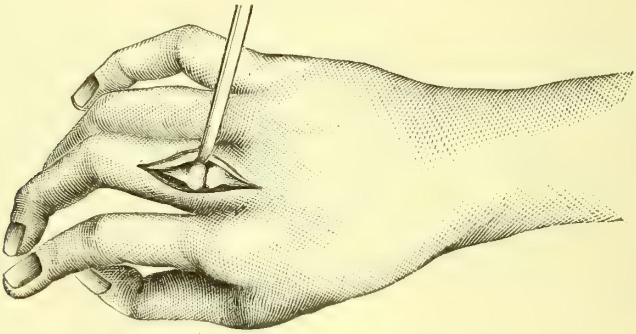
[1] See table on page 444.

[2] Op. cit., page 624.

the metacarpal bone of the thumb is the part to be removed, disarticulation may be first effected at either end, as may be found most convenient. (Fig. 714.)

Excision of a *metacarpo-phalangeal joint*, which may be required either for compound fracture or dislocation, or for disorganizing disease, may also be satisfactorily accomplished through a longitudinal, dorsal incision, the tendon being held out of the way, and the bones divided, either before or after disarticulation, with cutting forceps. (Fig. 715.) For excision of the *interphalangeal joints*, a similar operation may be practised, but in this locality the longitudinal incision should be made on one or other side, instead of on the dorsal surface.

Fig. 715.



Excision of metacarpo-phalangeal joint.

These operations commonly result favorably as regards the life of the patient, 114 terminated cases of resection of the bones of the hand for gunshot injury, tabulated by Drs. Otis and Huntington,[1] having given 11 deaths, a mortality of less than 10 per cent. But a finger that has lost its metacarpal bone or metacarpo-phalangeal joint, commonly becomes distorted and shortened, and not only is the symmetry of the hand lost, but its functions are more or less seriously interfered with.

Metacarpal excisions may be sometimes required in connection with partial amputations of the hand, but no general rules can be given for their performance under such circumstances.[2]

EXCISIONS IN THE LOWER EXTREMITY.

EXCISION OF THE HIP-JOINT.—This operation may be required in cases of injury (especially from gunshot wound), or of hip-disease, and possibly in some cases of necrosis of the upper part of the femur, though in that affection it would usually be right to wait for the spontaneous separation of the dead portion, which could then be removed with comparatively little risk. Excision of the hip has also been performed in cases of malignant disease, of anchylosis, and of rheumatoid arthritis. If anchylosis in a bad position be accompanied, as it sometimes is, by extensive caries, the operation may be properly resorted to as a means of relieving both conditions, but under other circumstances subcutaneous osteotomy, by Mr. Adams's or Mr. Gant's method, would be preferable, as promising an almost equally good result, and as being attended with very much less danger. For the other conditions named, hip-joint excision seems to me an unsuitable operation. Dr. J. W. Howe, of New York, has recorded a successful excision of the hip for ununited fracture.

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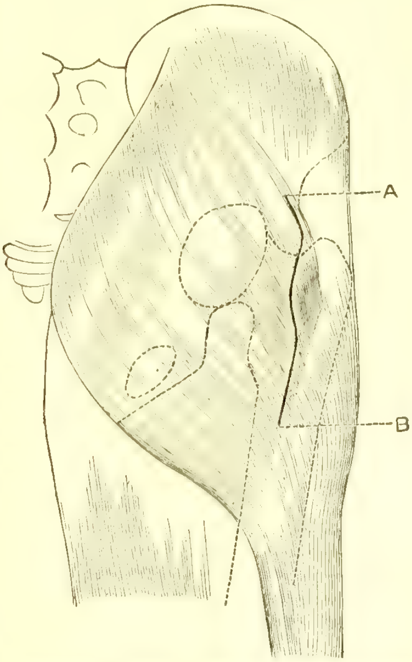
[1] Op. cit., Third Surgical Volume, page 875.

[2] See Vol. I., pages 634 *et seq.*

The first suggestion of hip-joint excision was made by Charles White, of Manchester, in 1769, but the operation was not actually performed until many years afterward, by Anthony White, of London, in 1822. The case recorded by Schlichting, in 1730, often spoken of as an excision, was a simple extraction of the caput femoris through a dilated sinus, and Schmalz's case, in 1816, was of the same character. Anthony White's case was one of deformity following the spontaneous cure of hip-disease, and a simple osteotomy would have been better than excision, which was, however, quite successful. The fatal operation attributed to Hewson, of Dublin, in 1823, appears to have been of the same character. The first excision for gunshot injury was performed by Oppenheim, in 1829; the first excision for necrosis by the elder Textor, in 1834; and the first excision for hip-disease by Sir Benjamin C. Brodie, in 1836. The operation was introduced in France by M. Roux, in 1847, and in this country by Prof. Bigelow, of Boston, in 1852. The first successful hip-excision in military practice was performed during the Crimean War by Surgeon O'Leary, in 1855.

Various incisions may be adopted for this operation: The single longitudinal, the curvilinear, the crucial, and the ⊢-shaped incisions, all have their advocates, but, upon the whole, I am disposed to give the preference to that recommended by O. Heyfelder, the peculiarities of which can be seen from the annexed illustration. (Fig. 716.) The wound begins a little above and behind the great trochanter, towards which it passes in the line of the fibres of the gluteus maximus muscle, and then, curving around and behind the trochanter, extends downwards and a little backwards, terminating over the linea aspera between the insertions of the gluteus and the vastus externus. By this incision, two irregular flaps are formed, the loosening of which affords abundant room for the future steps of the operation, while it entails no transverse division of muscular fibres. If spontaneous dislocation have already occurred, the head of the bone may now probably be at once protruded through the wound, but under other circumstances, the capsule of the joint must be opened, and the ligamentous structures cautiously divided with the probe-pointed knife; in cases of hip-disease, the ligamentum teres will have usually disappeared, but in traumatic cases it must be severed before the caput femoris can be protruded. The head and neck of the bone being free, the femur is to be rotated first in one direction and then in the other, while the muscles attached to the trochanters are shaved off close to their insertions, and the limb is then forcibly adducted and pushed upwards, so as to make its upper extremity project through the wound, when it is cut through with the chain-saw just below the great trochanter. (Fig. 717.)

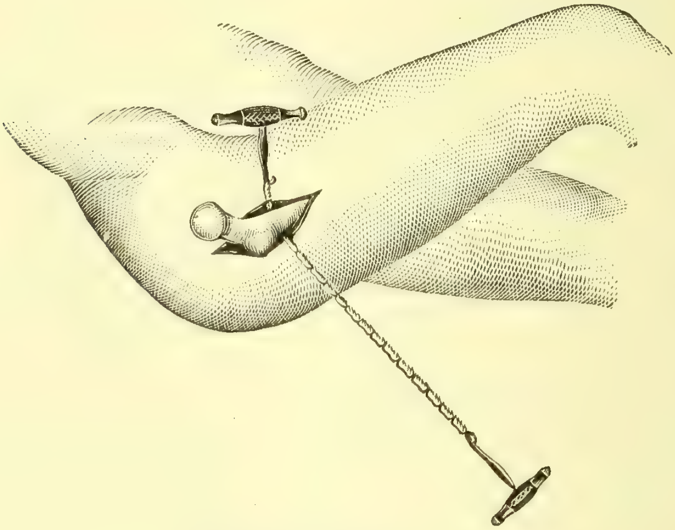
Fig. 716.



Heyfelder's incision for excision of the hip-joint.

Prof. Sayre, who lays great stress upon the importance of a sub-periosteal excision, divides the periosteum transversely with a strong-bladed knife, somewhat like an "oyster-knife," separates the membrane with an elevator, and saws through the bone *in situ* with a straight saw, before disarticulating; but my own experience leads me to think, with Mr. Holmes, that the subperiosteal method presents no particular advantages in this situation, and I believe that it is safer to effect disarticulation before applying the saw, in the way above described. In some cases, however, where there is firm anchylosis, this cannot be accomplished, and it may then be necessary to use the straight saw, and afterwards clear away the head and neck of the femur from the acetabulum with gouge and mallet.

Fig. 717.



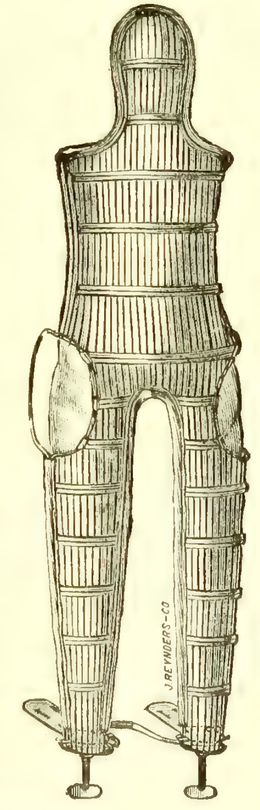
Excision of the hip-joint.

The great trochanter should, I think, always be removed, even if it be not itself diseased, as it is apt to become so subsequently, and may interfere with the healing of the wound by protruding between its lips. The lesser trochanter may also be cut away with bone forceps, if it seem very prominent, and it is well to trim the edges of the truncated shaft so as to round it off, and give it somewhat the form of the natural head of the femur. Care must be taken, in pushing up the caput femoris through the wound, not to fracture the shaft; this accident, which has occurred twice within my own knowledge, does no particular harm, as the bone reunites without difficulty, but it adds an inconvenient complication to the after-treatment.

The femur having been resected, the acetabulum and other exposed portions of the os innominatum are to be carefully examined, and any portions that are found carious or necrosed freely dealt with, loose fragments being extracted, and parts that are diseased but not loose removed with gouge or gouge-forceps, osteotrite, trephine, or small saw. Surgeons formerly thought that interference with the pelvic bones was unjustifiable, and that extensive pelvic disease therefore forbade the hope of successful excision; but Hancock, Erichsen, and others have shown that the acetabular form of hip-disease is almost as amenable to operative treatment as the femoral, and the whole bony floor of the acetabulum, and even large portions of the ischium and pubis, have, accordingly, been safely removed. As pointed out by Mr. Hancock, there is no danger that the pelvic cavity may be opened in these operations, since its inner wall, formed of muscles and fasciæ which are thickened and infiltrated with lymph, constitutes an efficient barrier to forbid the possibility of such an event.

The after-treatment of hip-joint excision is a very simple affair; free drainage must be provided for the wound, which should be closed with a few sutures and lightly dressed with oiled lint, covered with oiled silk, and the patient should be kept in bed for a few weeks, with the limb well abducted, so as to obviate any tendency to protrusion of the sawn end of the femur. Moderate extension should be made by means of a weight—from two to ten pounds, according to the age of the patient—which may be adjusted with the ordinary adhesive-plaster stirrup, employed in cases of fractured thigh, while lateral support is afforded by the apposition of sand-bags which should be covered with India-rubber cloth to prevent their becoming soiled by the discharges. The plan which I adopt is to place a bunch of oakum outside of the immediate dressing of the wound, and then put under the patient's hips and thigh a folded sheet or "slip-sheet," which is brought up between the patient's side and the outer sand-bag, so as to prevent the latter from coming in immediate contact with the limb. When the dressings are to be renewed, the weight is raised and the sand-bags are carefully lifted away, and while one assistant keeps up the extension, another gently rolls the patient on his sound side, when the wound can be cleansed and the fresh dressings adjusted with a minimum of disturbance. Prof. Sayre places the patient, immediately after the operation, in a somewhat formidable-looking wire "cuirass" (Fig. 718) modelled upon Bonnet's apparatus, which is padded to prevent excoriation, and provided with screws for making extension; but the simple appliances which I have described are so satisfactory that I have never felt disposed to employ any other.

Fig. 718.



Sayre's "cuirass," for after-treatment of cases of hip-joint excision.

As soon as the wound is sufficiently consolidated—usually in six or eight weeks—the patient should be allowed to sit up, and then to get about with crutches, or with one of the ingenious splints which have been devised for the treatment of hip-disease, and several of which have been figured in Mr. Barwell's article on Diseases of the Joints.[1]

The surgeon should not hastily abandon the hope of success, even if the wound do not unite promptly, and though suppuration continue profuse. Unless there be serious visceral disease at the time of, or developed subsequent to, the operation, careful dressing and judicious constitutional and hygienic treatment will almost always suffice to bring about ultimate recovery. *Re-excision* has occasionally been practised with advantage in these cases, and if the patient's powers of recuperation seem to be failing, the question of *amputation* may be properly entertained. As may be seen by the table on page 502, that operation has under such circumstances resulted favorably in at least seventeen out of thirty-one cases in which it has been resorted to.

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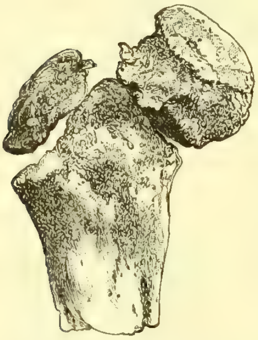
[1] See Figs. 665–669, pp. 395–397.

As was done in the case of the elbow, I shall further illustrate the subject of hip-joint excision by appending brief abstracts of a few cases selected from those in which I have myself had occasion to employ this mode of treatment.

The following case is of some local historical interest, as having been the second in which excision of the hip-joint had ever been done in Philadelphia, and the first which terminated successfully. Dr. Addinell Hewson was the pioneer in this procedure, in Philadelphia, having, in 1858, excised the left hip, in a girl of thirteen, at the Wills Hospital for the Blind and Lame; this case ended unfavorably, the patient sinking, exhausted by diarrhœa, seven months after the operation. No further attempt was made in this city to excise the hip-joint until I did it at the Episcopal Hospital, nine years subsequently.

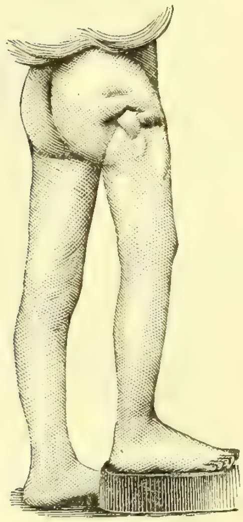
Excision of the Hip for Acute Hip-Disease with Abscess; Recovery with perfect Use of Limb.—W. E., aged four and a half years, was admitted to the children's ward of the Episcopal Hospital on June 15, 1866, suffering from hip-joint disease of the right side, of recent origin. I found him in the ward at the beginning of my term of service, in the month of January, 1867. On January 5, I find an entry in my note-book, that a large abscess was forming in connection with the joint. This abscess opened spontaneously ten days afterwards, and from that time the patient's health rapidly deteriorated. On February 27, 1867, with the assent and assistance of my colleagues, I excised the head and neck of the right femur, making the section a short distance below the trochanters, and removing in all about two and a half inches of bone. The incision employed was that recommended by O. Heyfelder (see Fig. 716), and the bone was divided partly with a chain-saw and partly with strong cutting forceps, the head of the bone separating from the neck in the process of removal, and the great trochanter, too, remaining adherent to the lower flap from which it was afterwards carefully dissected. The appearance of the excised portions of bone, which are now in the Hospital Museum, are shown in the annexed wood-cut. (Fig. 719.) The operation was greatly facilitated by the fact that dislocation had already occurred, the head of the femur being found displaced from the acetabulum to the dorsum ilii. The acetabulum itself presented very little evidence of disease, and was therefore not interfered with. Two ligatures only were required.

Fig. 719.



Head and neck of femur removed by excision.

Fig. 720.



Result of hip-joint excision.

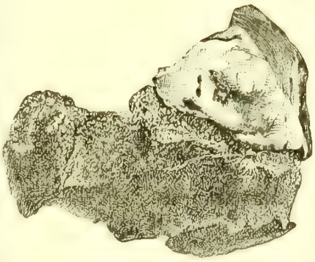
The patient's convalescence, though slow, was upon the whole satisfactory. His condition gradually improved, the greater part of the wound healing by adhesion, and his health and strength being little by little restored. One or two abscesses formed around the seat of operation, and were opened, and in the following summer the patient suffered a good deal from diarrhœa; but in spite of these complications a progressive amendment was observed in the child's state, both constitutional and local, and by January of the next year (1868) his recovery could be considered as established. His condition, thirteen months after the operation, was as follows: There were still several sinuses, which could not, however, be ascertained to communicate with diseased bone, and which, together, discharged on an average less than a fluidrachm of pus in the course of twenty-four hours. The patient could support a great deal of his weight on the affected limb, and could walk with one crutch, or the hand of an attendant. The power of flexion and extension of the limb was to a considerable degree restored, and the shortening of the thigh, by measurement, was but an inch and a half, although the amount of bone removed was quite two and a half inches in length. The child, six years old, was fat and hearty, and entirely free from all pain and suffering. He left the hospital on April 3, 1868.

I have seen this patient since, at long intervals, and about four years after the operation obtained the photograph from which the annexed wood-cut is taken. (Fig. 720.) His sinuses were then all soundly healed, and he walked briskly without assistance from my office to the photographer's. The last visit that I have had from him was about three years since—between thirteen and fourteen years, therefore, after the operation—when he told me that he was earning a livelihood as an operative in a mill, was in excellent health, and, except that he knew that one leg was shorter than the other, felt no difference between them; he engaged in all the active amusements and sports of his fellows, and, to use his own expression, could "walk with any one, run with any one, skate with any one, and swim with any one."

In the next case, although the patient was benefited, and his life probably prolonged, by the operation, the ultimate result of the case was unfavorable, the patient dying from tuberculous disease nearly a year after the date of excision:—

Excision for Hip-Disease of two years' standing; Recovery from Operation; Death from Visceral Disease more than eleven months subsequently.—T. M., aged nine years, came under my care at the Children's Hospital in the autumn of 1870. He was suffering from hip-disease of the left side, the malady having reached the third stage, and two sinuses, which communicated with the joint, discharging, one on the anterior and the other on the posterior surface of the thigh. The duration of the disease had been two years, and that of the abscess eighteen months. The patient's health was failing. On October 14, 1870, I removed the upper extremity of the femur by Heyfelder's incision, dividing the bone just below the trochanter with a chain-saw, and then gouged the carious rim of the acetabulum, which was the only part of the pelvis affected. The head of the femur had almost wholly disappeared, and the long-continued inflammatory action had caused a marked change in the direction of the neck of the bone. (Fig. 721.) No ligatures were needed; the wound was dressed with oiled lint, and the weight and sand-bags applied in the manner already described. Convalescence was slow, but by January, 1871, the patient was walking with crutches, and a month afterwards with a single crutch and high-soled shoe. Everything went well until the next June, when the patient was attacked with diarrhœa of an exhausting character. In August, he was removed from the hospital by his parents, contrary to advice, and was evidently neglected by them in a shameful manner, for he was brought back the next month in a most deplorable condition, with the wound reopened and the bone protruding. He died September, 27, 1871, and an autopsy showed, besides some roughness of the os innominatum, tubercle in both lungs and in the right kidney, with fatty and amyloid degeneration of the liver.

Fig. 721.

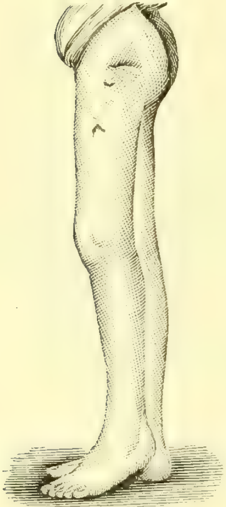


Bone removed in hip-joint excision, showing change in cervix femoris.

In the following case, while the local condition was that of advanced hip-disease, there was no visceral complication, and the result of the operation was everything that could be wished for:—

Excision of Hip for Coxalgia of nearly two years standing; Recovery with perfect Use of Limb.—A. H., aged fourteen, was admitted under my care, at the Children's Hospital, on September 15, 1875. He was suffering from hip-disease of the left side, of twenty months' duration, several sinuses opening on the outer, and one on the inner side of the thigh; there was partial anchylosis, the limb being very much shortened and everted; the patient had been unable to walk from the beginning of his malady, and yet was in fairly good general health. On September 23, I operated by Heyfelder's method, finding the head of the bone spontaneously separated, and a considerable formation of new bone from the periosteum around the neck. The femoral medulla was very soft and diffluent, but red—not purulent. The bone-section was made below the trochanters, the periosteum being preserved, and then the edge of the acetabulum, which was carious, was freely gouged and scraped. No ligatures were required, but there was rather free capillary oozing, which continued in slight amount through the next day. There was a moderate degree of traumatic fever, the thermometer on the evening of the second day marking 102° Fahr. The wound united solidly by adhesion almost throughout its entire length, and convalescence proceeded rapidly. In three weeks, the patient could draw up his limb by his own efforts, and in two months from the day of operation began to walk with crutches. On February 1, 1876, I find a note that he could walk with one cane, and on March 1, that he could walk a little without a cane, wearing a high-soled shoe. In June he was sent to the Children's Sea-shore House, at Atlantic City, whence he returned in August, walking readily without any assistance, and with the wound and all sinuses healed except at one point. The photograph from which Fig. 722 is copied, was taken September 13, 1876, ten days less than a year from the date of excision.

Fig. 722.



Result of hip-joint excision.

In the following case, as in that of T. M., the patient may be said to have recovered from the operation, only to die some months later from visceral disease:—

Excision for Hip-Disease of long standing; Recovery from Operation; Subsequent Death from Visceral Complications.—R. S., a young Irishman, twenty years of age, a cabinet-maker by trade, was admitted to the Episcopal Hospital on January 3, 1876, suffering from hip-disease of between four and five years' duration. For two years he had been incapacitated from work, but fibrous anchylosis in a good position was occurring, when an over-zealous surgeon in another hospital thought to restore motion to the part by breaking up the existing adhesions. This attempt was productive of no benefit whatever, but on the contrary, resulted in the formation of a large abscess, which opened spontaneously a few days after the patient came under my care. For several weeks, under careful treatment, there seemed to be some improvement, but this did not continue, and the patient then failed so rapidly that by the middle of March it was evident that unless the disease could be arrested by an operation, the case would ere long terminate fatally. On March 15, therefore, I excised the hip in the usual way, and the patient again began to improve. In May, I find a note that the wound was cicatrizing, and the discharge steadily lessening; in June, the patient sat up, and in July, began to walk with crutches; but it was now observed that his legs were becoming œdematous, and that his urine contained albumen. He went home, by his own request, shortly after this time, and I believe died some months subsequently, doubtless from amyloid disease of the liver and kidneys.

In the following case, both the age and constitutional condition of the patient, and the long duration of the disease, rendered the prognosis more than ordinarily grave, and yet the operation succeeded in giving the patient an excellent limb, and several years of useful activity:—

Excision of the Hip-Joint for Hip-Disease of eight years' duration; Recovery with useful Limb.—D., twenty-one years of age, applied to me at the University Hospital, in December, 1878, suffering from hip-disease of the right side, of eight years' standing. He walked with difficulty, with crutches, and was weakened by the continual discharge from open sinuses, while a large cicatrix over the sacrum marked the site of a former bed-sore. He was unable to work, and was consequently dependent for his support upon a sister who could ill afford to maintain him out of her wages as a maid-servant. Under these circumstances, I did not hesitate to recommend an operation, and accordingly performed excision in the usual way, before my clinical class, on December 21, 1878. The operation presented no unusual features, and except that there was profuse suppuration afterwards, and a good deal of trouble from bed-sores, the patient's convalescence was uninterrupted by any special complication. The cure was completed in about six months, when the photographs were taken from which the annexed illustrations (Figs. 723, 724) are copied. They show on the one hand the amount of shortening which followed the operation, and on the other the free range of motion which the patient had acquired. After his recovery he was employed in the hospital as a door-keeper and messenger, and the speed and agility with which he ran along the corridors, and up and down the long staircases, were a constant source of surprise to those who knew his history. After a time, I regret to say, he fell into bad habits, and Bright's disease was developed and ultimately proved fatal.

Fig. 723.

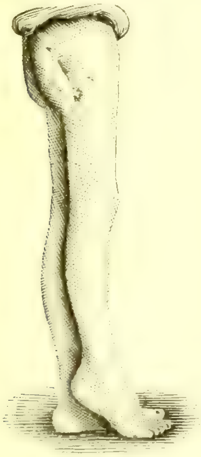
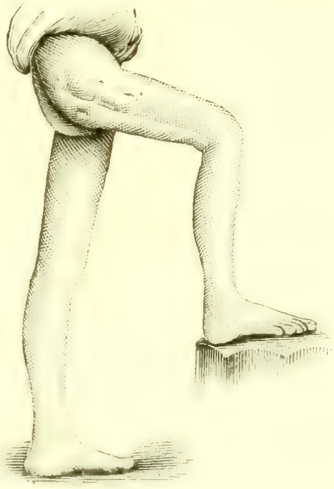


Fig. 724.

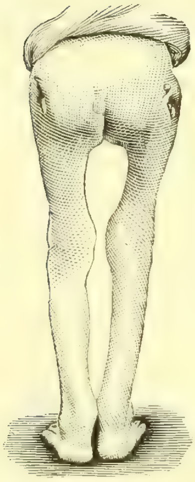


Result of hip-joint excision.

Once have I had occasion to excise *both hip-joints* in the same patient—the first instance, I believe, in which the double operation has been resorted to, though similar cases have been since recorded by Mr. Croft and Dr. Byrd. The result, in my case, was satisfactory as regarded the life of the patient, but he was not able to walk without crutches as long as he remained under my observation.

Excision of both Hip-Joints for Double Hip-Disease; Recovery.—C. G., a boy between eleven and twelve years of age, was admitted to the Children's Hospital in the autumn of 1872, suffering from hip-disease of *both sides.* In the *right* hip, the malady was of eight months' duration and in its second stage, but in the *left* hip was advanced to the third stage, with an abscess discharging behind the great trochanter. The boy's general health was much impaired by long-continued pain and suppuration. On September 9, 1872, I excised the left hip in the usual way, and removed a sequestrum from the acetabulum. The patient recovered rapidly from the operation, and by January, 1873, the wound was entirely healed. The disease on the right side, however, had meanwhile been progressing, and in April an abscess had formed and had undergone spontaneous opening, so that on the 23d of that month—seven and a half months after the preceding operation—I performed excision on the right side also. The head of the femur on this side was carious, but the acetabulum was healthy. A slight

Fig. 725.



Result of excision of both hip-joints.

reactionary hemorrhage occurred some hours after the operation, but was readily controlled by the application of cold and pressure; the greater part of the wound united by adhesion, but on May 4 and May 5 (the eleventh and twelfth days) there were free secondary hemorrhages, which left the patient quite blanched and exhausted. The bleeding did not recur, however, after this date, and convalescence though slow was henceforth uninterrupted. In August, 1873, the patient was sitting up, and able to work his way along the floor by leaning upon the back of a chair. In October, he could walk pretty well with crutches. He went home in April, 1874, and in October of that year I heard from him as still improving, though still requiring artificial aid in locomotion. The photograph from which Fig. 725 is copied was obtained before he left the hospital.

I have, in all, excised the hip-joint 21 times, in 20 patients, with 13 recoveries, 2 cases still under treatment, and 6 deaths, only one of which, however, appeared to have been hastened by the operation. Indeed, in two of the fatal cases, the patients may, as already mentioned, be fairly considered to have recovered from the operation, though dying from visceral disease many months afterwards. The particulars of these 21 cases are compendiously exhibited in the annexed table:—

TABLE SHOWING THE PARTICULARS OF TWENTY-ONE CASES OF EXCISION OF THE HIP-JOINT FOR HIP-DISEASE.

No.	Sex and age.	Duration of disease before operation.	Result; duration of treatment after operation.	Remarks.
1	Male, 5	One year	Recovered; 3½ years	Perfect use of limb.
2	Male, 9	Two years	Died; nearly 1 year	Death from phthisis.
3	Male, 11	Eight months	Recovered; 19 months	These two operations on same patient; case of double excision.
4	Male, 12	Fifteen months	Recovered; 1 year	
5	Male, 5	Two years	Recovered; 7 months	Removed from hospital before utility of limb determined.
6	Male, 4	One year	Died; 3½ months	Death from tuberculous meningitis.
7	Male, 14	Twenty months	Recovered; 1 year	Perfect use of limb.
8	Male, 20	Five years	Died; 6 months	Death from visceral disease.
9	Female, 7	Eighteen months	Recovered; 3 years	Useful limb.
10	Female, 8	Two years	Recovered; 3½ years	Useful limb.
11	Female, 10	Three years	Recovered; 6½ months	Useful limb.
12	Female, 8	Three years	Recovered; 5 months	Useful limb.
13	Male, 14	Several years	Recovered; 2 years	Useful limb.
14	Male, 6	One year	Recovered; 1½ years	Useful limb.
15	Male, 21	Eight years	Recovered; 6 months	Useful limb.
16	Female, 10	Four years	Died; 2 weeks	Death from diarrhœa and exhaustion.
17	Male, 9	Five years	Recovered; 2 months	Still used crutches when discharged.
18	Male, 17	Several years	Died; 4½ months	Death from phthisis.
19	Male, 17	Many years	Died; 3 months	Death from phthisis and exhaustion.
20	Male, 6	Two years	Still under treatment	Doing well.
21	Female, 8	Two years	Still under treatment	Complicated by pelvic abscess.

The statistics of hip-joint excision have been particularly studied by several authors, myself included, but the largest number of cases yet tabulated is embraced in Dr. Culbertson's well-known prize-essay, already so often referred to. The effect of *age* in influencing the result of the operation is as clearly marked as in the case of other articulations, the most favorable period of life for this excision being that between the ages of five and ten years, and the mortality in adult life being so large as only to justify the operation in exceptional instances. To illustrate this point, I have compiled the following table from Dr. Culbertson's figures of excisions for disease:—

TABLE SHOWING RESULTS OF EXCISION OF THE HIP-JOINT FOR HIP-DISEASE AT DIFFERENT AGES.

Age.	Total.	Recovered.	Died.	Result undetermined.	Mortality per cent. of terminated cases.
Under 5 years	51	29	18	4	38.3
Between 5 and 10 years	162	102	48	12	32.0
" 10 " 15 "	85	40	35	10	46.7
" 15 " 20 "	52	22	26	4	54.2
" 20 " 30 "	39	11	22	6	66.7
Over 30 years	26	9	14	3	60.9
Age not stated	55	21	29	5	58.0
Aggregates	470	234	192	44	45.1

The effect of the patient's *constitutional condition* upon the result of the operation is, perhaps, less obvious than in the case of the other joints, for the reason that the subjects of hip-excision are, with few exceptions, all in impaired health. It may be said, however, that advanced visceral disease and exhaustion from long-continued and profuse suppuration, greatly diminish the chances of recovery, and that the most promising cases are those in which, in spite of the local disease, the patients have maintained a fair state of general health. At the same time, statistics lend no support to the views of those who advocate early excision in the treatment of hip-disease, Dr. Culbertson's figures showing very clearly that the operation is most successful in cases of from 9 to 18 months' duration:—

TABLE SHOWING RESULTS OF EXCISION OF THE HIP-JOINT IN CASES OF HIP-DISEASE OF DIFFERENT DURATION.

Duration of disease.	Total.	Recovered.	Died.	Result undetermined.	Mortality per cent. of terminated cases.
Under 3 months	5	...	3	2	100.0
Between 3 and 6 months	20	9	10	1	52.6
" 6 " 9 "	10	5	5	...	50.0
" 9 " 12 "	30	19	9	2	32.1
" 12 " 15 "	10	10	...	...	0.0
" 15 " 18 "	15	10	5	...	33.3
Over 18 months	165	99	57	9	36.5
Duration not stated	215	82	103	30	54.9
Aggregates	470	234	192	44	45.1

As in the case of the other joints, hip-excision is more successful when employed for *disease* than when for *injury*. The operation is almost never required for the relief of accidents met with in civil life, but the two cases of this kind referred to by Dr. Culbertson both terminated fatally, while in military practice, the mortality of the procedure, as shown by the table on page 444, has been no less than 86.5 per cent. Comparing this with the death-rate of excision for disease (45.1 per cent.), we see that whereas in cases of the latter category more than half recover, in those of the former nearly nine-tenths die.

Partial excision—that is, removal of the upper end of the femur only—is somewhat more successful than *complete excision*, but the difference is so slight that the surgeon should not hesitate to take away all that is diseased. Dr. Culbertson's figures show that simple decapitation of the femur is less successful than excision embracing the neck and trochanters, as well as the head of the bone.

TABLE SHOWING COMPARATIVE RESULTS OF COMPLETE AND PARTIAL EXCISION OF THE HIP FOR HIP-DISEASE.[1]

Form of Excision.	Total.	Recovered.	Died.	Result undetermined.	Mortality per cent. of terminated cases.
Complete excision	177	90	77	10	46.1
Partial excision	241	124	97	20	43.9
Form not stated	52	20	18	14	47.4
Aggregates . . .	470	234	192	44	45.1

The *ultimate result* of hip-joint excision, as regards the utility of the limb, is in most cases quite satisfactory; in three of the four cases in Prof. Gurlt's tables, the end-result was "good," and in the remaining one "very good;" while of the 234 cases of recovery tabulated by Dr. Culbertson, there were 72 in which the result was "perfect" (30.8 per cent.), 106 in which the patients obtained "useful" limbs (45.3 per cent.), and only 13 absolute failures (5.6 per cent.), the utility of the preserved limb not having been noted in the remaining 43 (18.4 per cent.). Among my own cases—excluding that of double excision—11 instances of recovery have given 2 "perfect" and 7 "useful" limbs, while in the other two cases the patients passed from observation before this point could be determined.

Taking, however, all cases of excision for hip-disease together, the results of the operation cannot be said to be very brilliant, one out of three dying under the most favorable circumstances as to age, etc., and but a little over three-fourths of those who recover from the operation having been known to have useful limbs. Should then the operation be abandoned? I answer, certainly not. The question should be, not, what does excision promise, but rather, does any other mode of treatment promise as much? What, in fact, can those surgeons who oppose hip-joint excision offer in its place? The operation is, indeed, such a grave one, under any circumstances, that I do not consider a resort to it justifiable in any case in which it is not evident that life will be imperilled by longer persistence in expectant measures. A considerable number of cases of hip-disease run a mild course from beginning to end, and, with, or even without, treatment, terminate in spontaneous recovery, with more or less stiffness and deformity, it is true, but nevertheless, with fairly useful limbs; and even if an abscess forms, it by no means follows that a cure is to be despaired of. But in the majority of cases in which suppuration has occurred, there comes, sooner or later, a time when the only alternatives are excision, amputation, or a prolonged and fatal illness terminated by death. These patients very seldom—at least in the class of cases seen in hospital practice—recover under expectant treatment; they are carried from one hospital to another, and at last die worn out by suppuration or visceral disease, or are carried off from a life of pain and weariness by some intercurrent affection. Thus, twelve cases, observed by Gibert at the Hospital "Sainte-Eugénie," furnished eight deaths, three "not cured," and only one recovery. No one, probably, at the present day, would think it proper to *amputate* in any case of hip-disease in which excision was at all applicable; and, indeed, not to speak of the mutilation necessarily caused by hip-joint amputation, the mortality after this operation is not inconsiderable, at least nine out of thirty-four recorded cases of primary amputation for hip-disease having proved fatal; so that *excision* is, in a good many instances, the only available resource, and, as such, the surgeon should employ it without hesitation. In this respect excision of the hip-joint may be said to differ from that of any other articulation, and, as justly remarked by Mr. Holmes, "in cases which show a decided tendency to get worse, we may pretty confidently reckon all the recoveries after the operation as a clear gain."

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[1] Culbertson, op. cit.

As may be seen by the table of cases under my own care, the after-treatment of hip-joint excision is sometimes greatly protracted. As long as the patient does well, and, if not gaining, is at least not losing ground, the surgeon must not despair, but should persevere with careful dressing and judicious constitutional and hygienic treatment, by the aid of which an ultimate cure may be hoped for. If, however, the discharge increase, and it be evident that caries has recurred, and is too extensive for spontaneous recovery, a *re-excision* may sometimes be practised with advantage; or, if, with the same local condition, the patient's general health begin to fail, *consecutive amputation* may be still looked to as a last resource, and may be practised with a reasonable hope of benefit, thirty-one recorded cases of this kind having given at least seventeen favorable results.

The following tables embrace thirty-four cases of *primary* and thirty-one of *consecutive* amputation at the hip-joint for hip-disease:—

CASES OF PRIMARY AMPUTATION AT THE HIP-JOINT FOR HIP-DISEASE.

No.	Operator.	Result.
1	Alexander	Recovered
2	Allen	"
3	Baffos	Died
4	Bœckel	Recovered
5	Cowell	"
6	Cumming	"
7	Curling	Died
8	Id.	Recovered
9	Davy	"
10	Duffee	"
11	Foulis	"
12	Hughes	Undetermined
13	Hutchinson	Recovered
14	Id.	"
15	Id.	Died
16	Id.	"
17	Kerr	"
18	Lee	Recovered
19	Mack	"
20	Macnamara	"
21	Maisonneuve . . .	"
22	Marshall	"
23	Mason	"
24	Richardson	"
25	Rivington	"
26	Id.	Died
27	Secourgeon	"
28	Spofforth	Recovered
29	Stokes	"
30	Stout	"
31	Tay	"
32	Thompson	Died
33	Wheatcroft	"
34	Young	Recovered

Cases of Amputation subsequent to Excision of the Hip-joint for Hip-disease.

No.	Operator.	Result.	No.	Operator.	Result.
1	Alexander . . .	Recovered	17	Holmes . . .	Died
2	Id. . . .	"	18	Hulke . . .	Undetermined
3	Armstrong . . .	Died	19	Jackson . . .	Recovered
4	Barwell . . .	Recovered	20	Lucas	Undetermined
5	Id. . . .	Died	21	Lyon	Recovered
6	Bellamy . . .	Recovered	22	Marshall . . .	Died
7	Bruns	Died	23	Id. . . .	Recovered
8	Davy	Recovered	24	Id. . . .	"
9	Dawson . . .	Undetermined	25	Murbach . . .	"
10	Elkington . . .	Recovered	26	Parker	"
11	Garden	"	27	Smyth	"
12	Gay	"	28	Spence	"
13	Gould	Died	29	Swain	Undetermined
14	Heyfelder . . .	"	30	Teale	Recovered
15	Holmes . . .	"	31	Whitehead . . .	Died
16	Id. . . .	"			

Frosch has collected statistics of hip-joint excisions done with antiseptic precautions, and finds that one hundred and sixty-six cases gave seventy-six recoveries and forty-four deaths, the result in the remaining forty-six not having been ascertained. The mortality of terminated cases, according to these figures, was, therefore, 36.6 per cent., or 5 per cent. more than that in my own list of cases, in which no attempt was made to adopt Listerian measures. The fact is that the mortality after this operation is almost exclusively due to constitutional conditions, and very little dependent upon the management of the wound.

Resection of the Femur.—Excision in the continuity of the femur is an operation seldom called for or justified. In cases of compound fracture, the choice should rather be between pure expectancy (with removal of loose fragments, etc.) and amputation, and in cases of necrosis, when anything more than extraction of sequestra is necessary, ablation of the limb should be resorted to. Resection may be practised for the relief of ununited fracture, but in this part of the body is both a doubtful and a dangerous remedy, and, should milder measures fail to secure union, the patient will, as a rule, do well to be satisfied with the adoption of some mechanical means of support, such as that devised by Professor H. H. Smith, of Philadelphia,[1] rather than undergo the risks of a resection. Excision of a wedge-shaped portion of bone, as originally practised by Barton for bony anchylosis of the knee, has been probably more successful than any other form of resection in this situation, but is a less desirable operation than simple osteotomy, as recommended by Mr. Barwell,[2] and I must say the same of the operations for removing a disk of bone practised by Rodgers, Sayre, and Volkmann, in cases of bony anchylosis of the hip.[3] Resection of one femur, to compensate for shortening in the other, was proposed and practised by Meyer, of Wurzburg, and his example has been occasionally imitated by other operators—a reckless form of surgery which seems to me quite without justification.

If the operation of femoral resection is to be done at all, it may be accomplished by making a longitudinal incision on the outer side of the limb, exposing the bone, and then removing as much of the latter as may be thought desirable, with a chain-saw.

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[1] See p. 59, fig. 588.

[2] See p. 415.

[3] See pp. 412, 413.

The *statistics* of the operation present rather a melancholy picture. Of 175 cases tabulated by Drs. Otis and Huntington,[1] in which resection in the shaft of the femur for *gunshot injury* was performed during the American war, no less than 116 terminated fatally, a percentage of terminated cases of 69.4; the operation in Military Surgery is therefore much less successful than amputation of the thigh, the death-rate of which operation is given by the same authorities as 54.2 per cent.[2] Of 17 cases collected by Heyfelder,[3] in which the operation was performed for *ununited fracture*, there were 10 successful and 1 "half successful," while 1 required subsequent amputation, and 5 ended in death (29.4 per cent.); and even the cuneiform operation of Barton (for anchylosis of the knee) has given 2 deaths out of 17 cases, a mortality of 11.8 per cent.[4]

Excision of the trochanter major may be required in cases of gunshot fracture, caries, or necrosis, and has been successfully performed by Tenon, Velpeau, Textor, Teale, Fergusson, Parker, of New York, and other surgeons. The bone may be exposed by a straight or curved incision, and the diseased parts removed with the gouge and forceps.

EXCISION OF THE KNEE-JOINT.—This operation is chiefly employed in cases of chronic disease of the articulation, though it has also been practised for compound fracture or dislocation, and for anchylosis, whether fibrous or bony; in the latter case by the method introduced by the late Dr. Gurdon Buck, of New York, and since described as "excision in a block." As already mentioned, knee-joint excision was first performed (successfully) by Filkin, of Norwich, in 1762, and again successfully by Park, in 1781. So little favor, however, did the operation receive at the hands of surgeons generally, that forty years ago it had been performed in all less than twenty-five times. Revived by Textor, in Germany, and by Sir W. Fergusson, in England—the last-named surgeon having operated for the first time in 1850—the operation has since been so largely employed that its statistics, in civil practice, are now considerably more extensive than those of any other excision. The first excision of the knee-joint in this country was performed by Dr. Kinloch, of Charleston, in 1856. The first knee-excision in Military Surgery was that of Fahle, in 1851.

Various incisions have been adopted for this operation, those which have met with most approval being the **H**-shaped, the semilunar or **U**-shaped, and the simple transverse incision. Treves, of Margate, has revived a suggestion of Jeffray and Sédillot, and advises that lateral incisions only should be employed, without any transverse wound.

The **H**-shaped incision was first employed by Moreau, has been adopted by Butcher, of Dublin, and is still preferred by some surgeons, including Prof. Hamilton, of New York. It consists of two longitudinal incisions, one on either side of the joint, with a transverse cut immediately below the patella. Provided that care be taken to place the lateral incisions far back, so as to allow of free drainage, this method answers a good purpose, and is certainly easier for the beginner than either of the other forms of operation; it, however, makes an unnecessarily large wound, and is, in my judgment, far inferior to the operation by transverse incision.

The **U**-shaped, horse-shoe, or semilunar incision (Fig. 726), was introduced by Mackenzie, and is now advocated by such high authorities as Prof. Humphry, of Cambridge, Prof. Erichsen, of London, and Prof. Gross and Prof. Agnew, of Philadelphia. This method consists in raising an anterior flap containing the patella, the base of the flap reaching to above the femoral condyles. The ligamentum patellæ is divided in the first incision, when, the crucial and lateral ligaments being cut, the articulating extremity of the femur can be readily excised with a Butcher's saw. The limb being then flexed and forcibly thrust upward, the extremity of the tibia can be made to protrude, and may be removed with the same instrument. This method makes a smaller wound than the H-shaped incision, but does not afford such free access to the joint.

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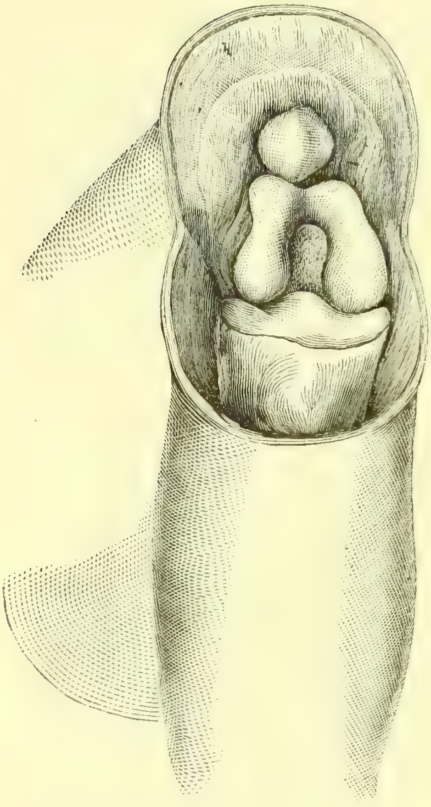
[1] Medical and Surgical History, etc., Third Surgical Volume, p. 875.

[2] Ibid., p. 877.

[3] Op. cit., p. 82.

[4] Culbertson gives 14 cases (op. cit., pp. 268–275), to which may be added three successful operations, respectively recorded by the late Dr. Blackman, of Ohio, Mr. J. E. Adams, of London, and Mr. Kilgarriff, of Dublin.

Fig. 726.



Excision of knee-joint by semilunar incision.

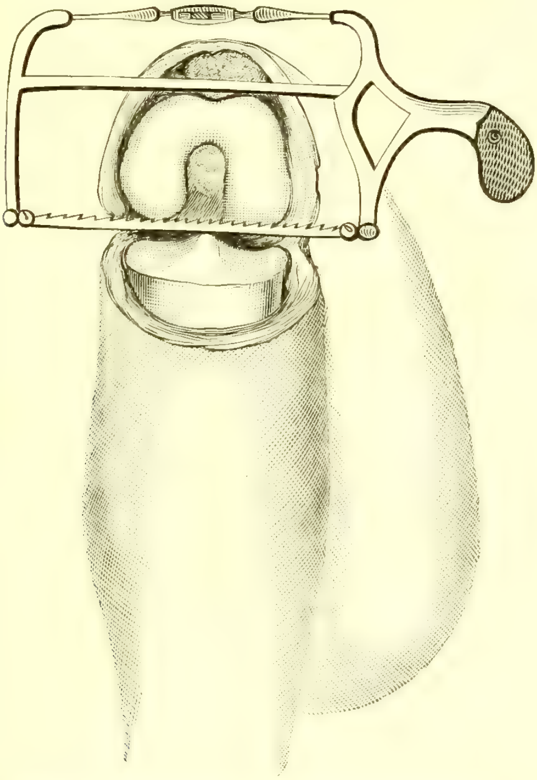
By far the best procedure, in my judgment, is that originally suggested by Park, in the postscript to his famous letter to Mr. Percival Pott, but which seems to have been first employed by Textor, Kempe, of Exeter, and Sir William Fergusson. It consists in making a single, transverse incision across the front of the joint, immediately below the patella, the extremities of the wound being carried well backwards, so as to ensure free drainage during the after-treatment. (Fig. 727.) When the limb is much contracted, as it often is in these cases, this incision, though made transverse to the axis of the tibia, forms, when the limb is extended, a somewhat obliquely curved wound with its convexity downwards, and thus really constitutes a flap operation. By dividing the ligamentum patellæ, the joint is opened, and the surgeon then proceeds to divide the lateral ligaments, and the crucial ligaments if any portion of these is remaining.

The next step is to clear the condyles of the femur for the application of the saw, and it is here ordinarily recommended to dissect back all the overlying tissues, including the patella, which is subsequently removed from within; but this, in cases in which the parts are much thickened and infiltrated, is a very troublesome business, and when it is accomplished the result is not very satisfactory, for the cavity left by removing the patella almost invariably suppurates, and, as a consequence, abscesses form, and leave persistent sinuses above the wound. Moreover, all that is really needed as a covering to the bone is the skin and subcutaneous fascia, and hence in all my more recent cases I have simply dissected these back to the level at which I meant to apply the saw, and have then cut directly down to the bone, thus removing together the extremity of the femur and the patella, with the diseased tissues by which the latter is surrounded.

For clearing the posterior surface of the condyles, I employ the strong probe-pointed knife with limited cutting edge, recommended by Mr. Erichsen (Fig. 679), having, I confess, a strong objection to the use of sharp-pointed instruments in the neighborhood of the popliteal vessels.

For making the bone-sections, I invariably employ Butcher's saw, reversing the blade so as to divide the bone from below upwards.

Fig. 727.

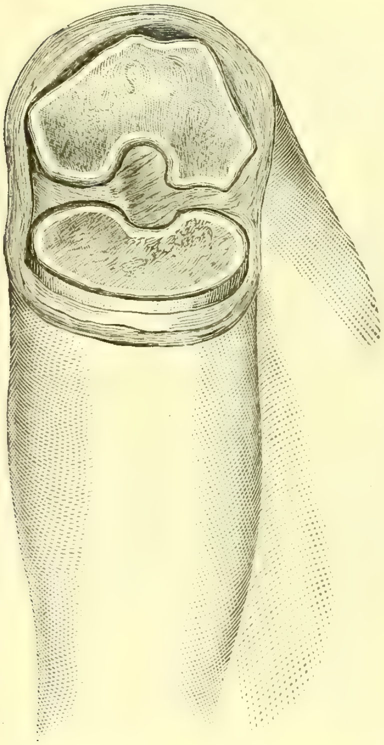


Excision of the knee-joint by single transverse incision.

In removing the articular extremity of the femur, it must be remembered that the internal condyle is situated lower than the external, and that hence the line of section must be parallel to that of the free surface of the condyles, and, therefore, oblique to the axis of the femoral shaft, as otherwise the natural inclination of the limb would not be preserved. As, too, the epiphyseal line is higher in front than behind, a safe rule is, that the condyles should be sawn in a plane, *which, as regards the axis of the femur is oblique from behind forwards, from below upwards, and from within outwards.* The tibia should be sawn in a plane transverse to the long axis of the bone, with a slight antero-posterior obliquity to correspond with that of the section of the femoral condyles. In order to avoid interfering with the epiphyseal junction, and thus hindering the future growth of the limb, care must be taken not to remove the whole of the condyles; it is quite sufficient to take away the anterior portion—that which articulates with the tibia in the position of extension—a slice varying from half an inch to an inch in thickness, according to the size of the bone. From the tibia a still smaller portion may be removed, all that is needed here being to obtain a smooth section to be opposed to that of the femur. It is a good plan to snip off the sharp posterior edges of both bones with cutting pliers, so as to avoid all risk of injury to the tissues of the popliteal space.

The bone-sections having been made (Fig. 728), the surgeon should examine the condition of the sawn surfaces, and deal with any softened or carious patches by the free use of the gouge and osteotrite. The same plan may be pursued with any portion of diseased bone or cartilage beyond the line of section.

Fig. 728.



Excision of the knee-joint; the operation completed.

The next step of the operation is to clip away, with scissors curved on the flat, or with Mr. Butcher's "knife-bladed forceps," any shreds of disorganized synovial membrane or ligament, taking care, however, not to disturb the floor of the wound, which should, if possible, be left intact.

The surgeon may next proceed to adjust the resected bones, when, if they cannot be brought into position by any justifiable amount of force, he should divide the hamstring tendons, and if this does not suffice, must remove an additional slice of bone.

All bleeding vessels having been carefully secured by ligature, the wound may be brought together by stitches, and the limb adjusted upon the splint which is to be employed during the after-treatment. This adjustment is, I think, best effected while the limb is elevated to nearly a vertical position, there being under these circumstances no difficulty in keeping the bones together, while, if brought down to a horizontal line, there is a constant tendency to displacement from the weight of the leg. The application of the splint should be completed before the patient is allowed to recover from the state of anæsthesia, which should be fully maintained during the whole operation.

Two points still require notice in regard to the operation itself: first, as to the control of bleeding during the operation, and second, as to the mode of dealing with the patella.

I employ no tourniquet nor other means of interrupting the circulation during the operation; no large vessel is divided, and I believe it much safer to tie each small artery as it is cut, than to run the risk (which is by no means only theoretical) of having consecutive hemorrhage from vessels which, under temporary compression, have retracted, and which do not bleed until the patient becomes warm in bed.

Even if the patella is not itself diseased, it should, I think, be removed; as the after-treatment aims at obtaining bony union, the patella is of no use, and statistics show that the risks of the operation are greatly increased by its retention. Pénières finds that while the removal of the patella diminishes the risk of death by nearly one-third, its retention more than doubles the probability of subsequent amputation becoming necessary.

Two variations in the mode of performing this operation deserve a brief notice. Mr. Golding Bird has recently suggested,[1] under the name of "transpatellar excision," that the patella should not be removed, but should be sawn across, its segments being turned upwards and downwards so as to expose the joint, and being finally re-approximated with carbolized silk sutures. I confess that this modification of the ordinary operation does not impress me as being an improvement. I see nothing to be gained by retaining the patella, while, on the other hand, if its retention were thought desirable, it could certainly be accomplished better by Jeffray's and Treves's plan, already referred to, in which only lateral incisions are made. The other variation is one of much greater plausibility, introduced by Prof. G. E. Fenwick, of Montreal, and consists in sawing both femur and tibia in a curved line, so as to make them fit together more closely and accurately than they would do otherwise. This mode of procedure has proved very successful in the hands of Dr. Fenwick himself, who has kindly furnished me with an account of his operation, which will be found at the end of this article.

One of the chief difficulties to be contended with during the after-treatment of knee-joint excision, is to prevent the anterior projection of the cut extremity of the femur; to obviate this, the surgeon may, particularly in cases of children, fix the bones in apposition by means of a strong metallic suture, as originally employed under these circumstances by the late Dr. Gurdon Buck, of New York. In operations upon adults, however, this will not, I think, usually be found necessary, particularly if the bone-sections be made, as above recommended, in a plane slightly oblique from behind forwards and from below upwards — a suggestion which appears to have originated with Billroth, and which is readily carried out with the aid of Butcher's saw.

The points specially to be considered with regard to the after-treatment, are the choice of a splint, the position in which the limb is to be kept, and the frequency with which it should be dressed.

An excellent splint for the after-treatment of knee-joint excisions, is that known as Price's, which consists of a posterior metal splint, cut away beneath the knee, with an arrangement by which it can be lengthened or shortened, a bracketed wooden external splint to guard against outward bowing (to which there is always a strong tendency in these cases), and a movable wooden foot-piece. The objections to Price's apparatus are its expense, and its complicated nature. Butcher's "box-splint" has answered a very good purpose in the hands of its introducer, but seems to me unnecessarily cumbersome, and the same may be said of the tin splint which is, I believe, generally used in Boston. Dr. Watson, of Edinburgh, employs a posterior moulded splint, with an anterior bracketed rod by which the limb can be suspended, and this splint, with slight modifications, is that preferred by Dr. Fenwick.

The splint which I used in my earlier operations was a bracketed wooden splint (Fig. 729), with a movable foot-piece, simplified, and as I thought improved, from that originally introduced into the Episcopal Hospital of Philadelphia, by my colleague, Dr. Packard, the latest development of whose apparatus is shown in Fig. 730. The great merits of this wooden splint were its simplicity and cheapness: it was, however, necessarily heavy, and, the wood getting saturated with the discharge, it became after a time offensive; hence of late years I have preferred the bracketed wire splint shown in Fig. 731, the splint being of course well padded, and the thigh, leg, and foot firmly fixed with broad strips of adhesive plaster and bandages. The essential points to be provided for are *absolute immobility of the limb* and *ready access to the wound*, and both of these requisites are perfectly secured by using the splint here described. When the splint has been adjusted, the limb should be laid on a pillow, or, better still, in a large and loose fracture box.

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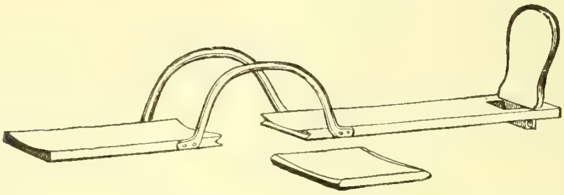
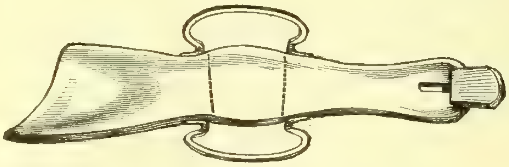
[1] Lancet, Jan. 20, 1883.

Fig. 729.



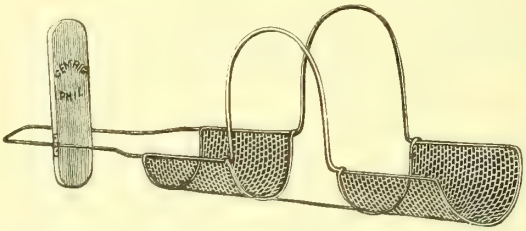
Bracketed wooden splint for after-treatment of excision of the knee.

Fig. 730.



Packard's splint for after-treatment of excision of the knee.

Fig. 731.



Bracketed wire splint for after-treatment of excision of the knee.

Any tendency to anterior projection of the femur may be counteracted, as advised by Mr. Butcher, by using in addition a short *anterior* splint, while the risk of outward bowing may be prevented by using an *external* splint, a metal spring and truss-pad, as ingeniously suggested by Mr. Swain, or, which I have found amply sufficient, a strip or two of adhesive plaster, looped around the outside of the limb and secured to the inner side of the splint.

In what position shall the limb be placed after excision of the knee? Some surgeons recommend a slightly flexed position, believing that a somewhat bent limb is more useful than a straight one. This I regard as an error; a stiff *unresected* knee is no doubt better when anchylosed at a slight angle, so as to enable the patient to walk without swinging out his limb like that of a compass; but by excision the limb is necessarily so much shortened as to obviate any risk of this compass-like motion, and, consequently, the straighter it can be made the better it will be for the patient. I have had the opportunity of comparing the results of both methods in practice, and have no hesitation in deciding in favor of the straight position.

No rule is more important in the treatment of these cases than that the limb should be undisturbed after the operation. The wound, of course, must be dressed daily, but when the splint is once applied there should be no necessity for readjustment until the process of bony union is well advanced; six weeks is none too long for the splint to remain without renewal, and under no circumstances should it be disturbed within the first fortnight. I believe with Price and Swain that a neglect of this rule has been answerable for many of the failures of knee-joint excision. In the later stages of the after-treatment I have found it convenient to replace the bracketed splint by a simple, moulded, pasteboard gutter, made to embrace the posterior half of the limb.

Should, unfortunately, caries or necrosis recur after excision, a *re-excision* may be properly attempted, or, if the patient's health be failing, *amputation* may be resorted to as a life-saving measure. Re-excision may also be required for *recurrent deformity with anchylosis*, and I have successfully employed it under these circumstances. In two cases have I known flexion of the limb to occur after recovery from knee-joint excision, when the bones were, to all appearances, firmly united. In the first case, I succeeded in straightening the limb without any difficulty by applying a posterior, straight splint, and an elastic bandage, which soon brought the knee down into position; but in the other case the patient was lost sight of for seven years, at the end of which time complete synostosis had occurred with the leg at a right angle to the thigh, and I then successfully re-excised after Buck's method (excision in a block), and the patient has now a straight and useful limb, though of course shortened by the double operation.

As in the case of other articulations, I shall endeavor to further illustrate the subject of knee-joint excision by giving abstracts of a few cases[1] from among those in which I have had occasion to perform the operation.

Partial Anchylosis with Recurrent Arthritis of Right Knee; Excision; Recovery with Useful Limb.—The portions of bone removed in this case were exhibited in their recent state to the Pathological Society of Philadelphia, at its meeting of March 24, 1870, and a brief note of the case appeared in the proceedings of that body.[2] The patient was a boy, ten years of age, who four years previously had received an injury of the right knee, and had been subsequently treated in various hospitals with but temporary benefit. When admitted to the Episcopal Hospital, where he came under my observation, in March, 1870, the joint was found to be markedly distorted, the limb being contracted to an angle of about 120°, the tibia dislocated backwards and upwards, and the patella firmly fixed upon the external condyle of the femur. There was partial anchylosis; the joint was tender and at times painful; and the frequent falls to which the boy was exposed by the inability to use his limb, led to oft-recurring attacks of inflammation, each of which left the part more crippled than it had been before.

Under these circumstances it was determined to resort to excision, and accordingly, on March 23, the patient being under the anæsthetic influence of ether, I made a single curved incision over the front of the joint, dissected out the patella, and, having with a probe-pointed knife fairly exposed the ends of the femur and tibia, removed their articulating extremities with the saw known as Butcher's, its blade being fixed so as to cut from below upwards, and thus to avoid all risk of injury to the important structures in the popliteal space. The disorganized soft tissues of the joint having then been clipped away with Butcher's knife-bladed forceps, a few small vessels were secured with ligatures, the edges of the wound were brought together with numerous points of the interrupted wire suture, and, the resected bones having been carefully adjusted, the limb was firmly fixed upon a well-padded, posterior, bracketed splint, the wound lightly dressed, and the patient restored to bed.

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[1] Several of these cases, as well as some of those of elbow-joint excision, were included in papers read before the College of Physicians of Philadelphia in 1875 and 1876. (Transactions, 3d series, vols. i. and ii.)

[2] Proc. Path. Soc. Phila., vol. iii. p. 164.

Fig. 732.

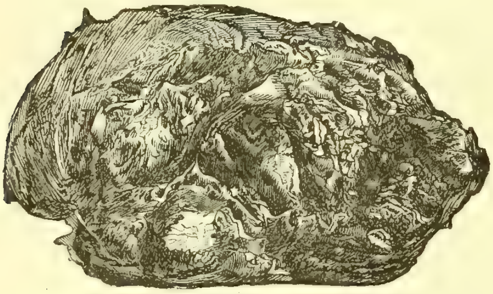
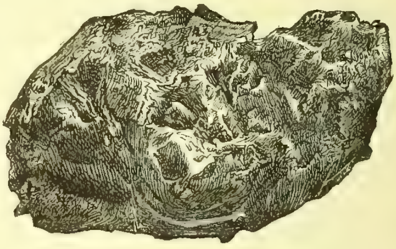


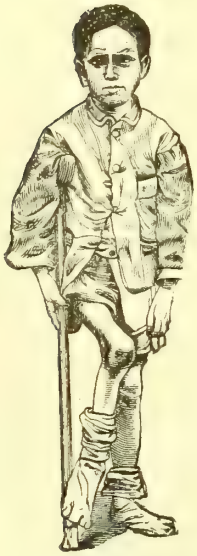
Fig. 733.



Articulating surfaces of femur and tibia removed by excision of the knee-joint.

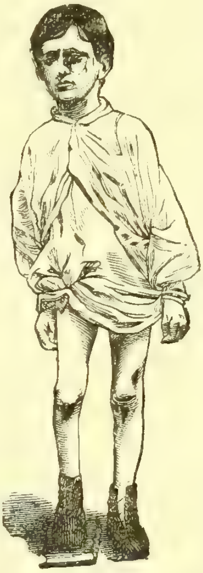
But little need be said as to the subsequent progress of the case; the wound was dressed daily, but the limb was not taken from the splint until cleanliness required its removal, and then the parts were firmly held by an assistant until the padding of the splint had been renewed, when everything was readjusted as before. When the union of the resected portions was sufficiently advanced, the bracketed splint was exchanged for a simple, moulded, pasteboard gutter, and this in turn was ultimately replaced by a soap plaster and bandage. The greater part of the wound healed by adhesion, and on August 18, 1870 (nearly five months from the date of operation), the patient was quite well, his leg firmly united at a slight angle, and able to walk without crutch, cane, or other assistance, and with no pain. The shortening of the limb was noted as two and three-quarters inches, but part of this was the result of a fracture of the thigh which had been received some years before.

Fig. 734.



Partial anchylosis and recurrent arthritis of knee. Before operation.

Fig. 735.



The same patient. Result of excision of knee-joint.

The appearances of the excised portions of bone, showing ulceration of the articular cartilages with erosion of the subjacent osseous tissue, may be seen in Figs. 732 and 733. The condition of the patient before and after operation is shown in Figs. 734 and 735.

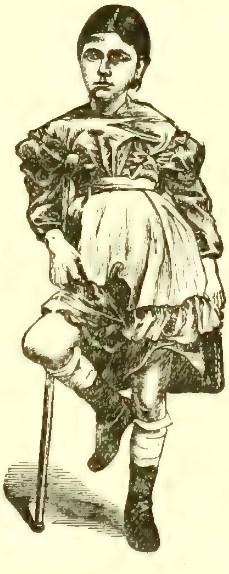
The above case is a fair example of a large number met with in practice, particularly amid the class of patients by whom our hospitals are chiefly filled. A stiff knee-joint, by itself, can seldom be thought to require so serious an operation as excision, the deformity being usually remediable by milder measures. But when imperfect anchylosis, in a bad position, is complicated by the frequent recurrence of arthritis, the case (provided that there be no contra-indication in the age and general condition of the patient) is one in which little or no benefit can be hoped for without operation, and in which excision may be resorted to with every prospect of a favorable result.

Arthritis of Knee of six years' standing; Limb deformed and useless; Excision; Recovery with Useful Limb.—The patient in this case was presented at a meeting of the College of Physicians of Philadelphia, held on February 21, 1872, and a note of the case appeared in the Transactions of that body.[1] The patient, Mary M., eleven years of age, was admitted to the Episcopal Hospital on February 24, 1871. At the age of five, she had suffered from smallpox, following which disease she had arthritis of both elbows and of the right knee. In the elbows, firm anchylosis ensued, and, the joints being flexed at convenient angles, she enjoyed very good use of her upper limbs. In the knee, however, the arthritis recurred from time to time (the last acute attack having been about two months before the date of the patient's entrance to the hospital), and the appearance of the joint, on her admission, was quite characteristic of advanced disease of the articulation. The knee was flexed to a right angle and much swollen, the subcutaneous veins enlarged, and the tibia dislocated backwards and outwards. The joint was tender on pressure, and painful when moved, and the patient thin and anæmic.

Excision was performed on February 28, 1871, a single transverse incision affording access to the joint; the parts removed were the condyles of the femur, the articulating surface of the tibia, and the patella. Five or six small vessels were secured with ligatures, the wound was closed with wire sutures and lightly dressed with oiled lint, and the limb was carefully adjusted upon the bracketed splint, which was not changed until some time in the fourth week.

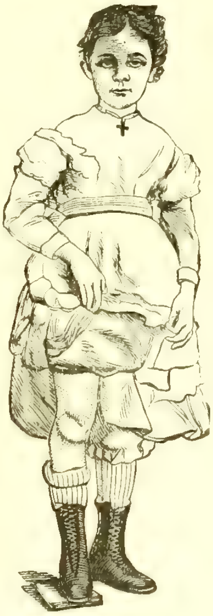
Convalescence was retarded by a profuse epistaxis which occurred a few days after the operation, leaving the patient blanched and exhausted, by rather profuse suppuration (several abscesses having formed above the site of excision), and by a troublesome diarrhœa which, beginning in the month of April, continued at intervals through the summer, and at one time became a really serious complication. Firm, bony union was completed about the third or fourth month, but several superficial sinuses persisted, and did not entirely heal until several months subsequently. A year after the operation the patient walked readily, without any assistance whatever, though with a perceptible limp due to the shortening, which was found by measurement to be an inch and three-quarters. She had grown considerably, was fat and hearty, and in every way offered satisfactory evidence of the advantages to be derived from this particular branch of conservative surgery. This patient has been frequently seen since her discharge from hospital, and it has been ascertained that the benefits derived from the operation have been permanent.

Fig. 736.



Arthritis of knee-joint. Before operation.

Fig. 737.



The same patient after excision of the knee-joint.

The accompanying illustrations (Figs. 736 and 737), from photographs, show the appearance of the patient before operation and after recovery.

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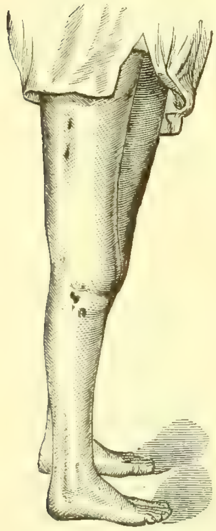
[1] Trans. Coll. Phys. Philada., 2d S., vol. iv. page 413.

In the next case, the disease, though of shorter duration, had run a more acute course, the joint having suppurated, and being open at the time of the operation.

Excision of Right Knee for Chronic Arthritis with Intra-articular Abscess; Recovery with Useful Limb.—The subject of this case, Henry S——, was a young man, eighteen years of age, who entered the Episcopal Hospital on January 4, 1872. He had been suffering from disease of the right knee-joint for one year, during the last three months of which the articulation had been suppurating and discharging externally. The joint was greatly swollen, and the surrounding soft parts much infiltrated with the products of inflammation, but as the diseased action seemed to be limited to the articulation itself, and as the patient's general condition was satisfactory, it was thought proper to make an attempt to save the limb by excision.

Accordingly, on January 11, 1872, the patient being thoroughly etherized, the joint was laid open by a single, transverse incision below the patella, when this bone was removed together with the articulating extremities of the femur and tibia, the articular cartilages on both of the latter being found to have been almost entirely destroyed. But two ligatures were required, and, the wound having been closed with wire sutures and dressed with oiled lint, the limb was carefully adjusted on a posterior bracketed splint in the usual way. The greater portion of the wound united by adhesion, and, though convalescence was delayed by the formation of several superficial abscesses, the progress of the case was upon the whole satisfactory.

Fig. 738.



Result of knee-joint excision; slight motion preserved.

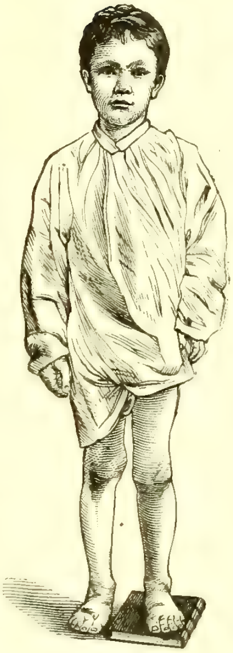
In January, 1873, one year after the operation, the patient walked with crutches, without any support to the resected limb, which was an inch and a half shorter than its fellow. There was still slight motion of flexion and extension at the knee, but no lateral movement whatever. There were two or three small sinuses, with superficial caries, but not connected with the site of excision. On January 21, the patient fell and sustained a fracture of the fibula of the resected limb, but did not injure the knee, thus furnishing a pretty good test of the sufficiency of the repair which had taken place. This accident was recovered from in a few weeks, and by March 25, the patient walked with a single crutch; on April 30, the sinuses were nearly healed, and he walked readily with a cane, and for short distances without even that support; and on May 4, he was made an out-patient. I heard from him afterwards at intervals, the last time about four years after the operation; his limb had long been healed, and he walked readily with a cane; he supported himself by peddling vegetables from a cart, and came several miles to town, twice a week, to go to the theatre.

The appearance of the resected limb is shown in the annexed illustration, from a drawing by Dr. Martinez. (Fig. 738.)

Though I have always endeavored to secure bony union after excision of the knee-joint (believing it to be safer to do so), yet I have in two cases succeeded in obtaining very useful limbs, while slight motion still remained in the direction of flexion and extension; indeed, provided that there be no lateral movement, such a result is by no means disadvantageous, the slight yielding of the limb antero-posteriorly enabling the patient, I think, to walk with a less apparent limp than if the part is entirely immovable.

Arthritis of Left Knee, the Result of Injury; Abscess communicating with Joint; Excision; Rapid Recovery with Useful Limb.—James H., a boy nine years of age, was admitted to the Episcopal Hospital on November 16, 1871, suffering from an "injury"—probably a contusion—of the knee, which was followed by arthritis, and by the formation of an abscess in the thigh, immediately above the joint, with which it subsequently communicated. This abscess had been opened in December, and in January, 1872, when I took charge of the case, I found the parts in a quiet condition, but the ligaments of the joint very much relaxed, and its structure evidently disorganized. Excision was performed in the usual way on January 25, the semilunar cartilages being found much diseased, though the articular surfaces of the femur and tibia were but slightly eroded. Only one ligature was required, and the limb was placed on a bracketed splint and dressed in the usual manner. The patient convalesced rapidly; osseous union occurred quickly between the resected bones; and the patient was discharged, cured, with an excellent limb, on June 12, 1872, about four and a half months after the date of excision. The result of the operation may be seen by the accompanying illustration (Fig. 739), from a photograph taken shortly before the patient left the hospital.

Fig. 739.



Result of knee-joint excision.

In the next case, as in that of Henry S., a most useful limb was obtained, although without the occurrence of bony union.

Excision of Left Knee-Joint for Arthritis of two years' standing; Recovery with Useful Limb.—Annie McS., nine years of age, entered the Children's Hospital on October 8, 1873, suffering from arthritis of the left knee, with partial anchylosis, and consecutive outward and backward dislocation of the tibia. The condition of her limb rendered her very helpless, and by preventing her from going to school seriously interfered with her acquiring an education. As her disease, moreover, was of two years' standing, and was manifestly too far advanced to offer much prospect of recovery without operation, immediate excision was determined upon, and was performed in the usual way on October 14, 1873, only one ligature being required, and the wound being dressed and the limb supported in the ordinary manner. The articular cartilages were found much eroded, and a patch of caries existed on the outer condyle of the femur. The appearances of the resected parts are seen in the annexed illustrations. (Figs. 740 and 741.)

Fig. 740.

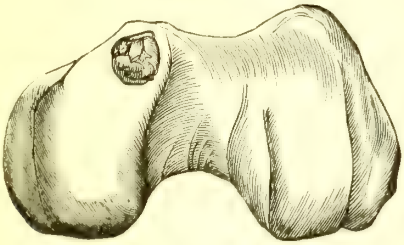
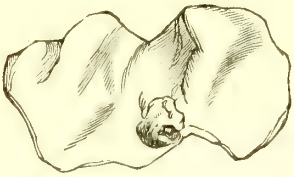


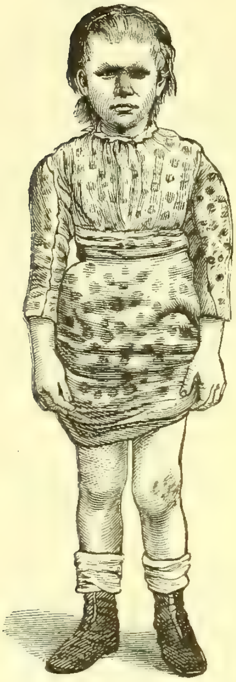
Fig. 741.



Parts removed in excision of the knee-joint.

The operation was followed by very little constitutional disturbance; an abscess, which formed above the excision wound, was opened on October 18; the sutures were removed on the 20th, and the ligature came away on the day following. Union between the resected surfaces had begun by October 26, and by December 12, the cure was sufficiently far advanced to allow the bracketed splint to be replaced by a simple, moulded, pasteboard gutter, and the patient to sit up. By March, 1874, though slight motion still existed as regarded flexion and extension, the patient was able to walk without any aid, the limb being simply supported with a soap-plaster and bandage. One superficial sinus, which healed very slowly, caused the patient to be kept under observation an unusually long time, and she did not finally leave the hospital until the summer of 1875 (nearly twenty months after the operation), previous to which she was presented at a meeting of the College of Physicians, and a photograph was secured, from which the annexed illustration (Fig. 742) is taken.

Fig. 742.



Result of knee-joint excision; slight motion preserved.

The case which follows is an example of that form of disease for which I have ventured to propose the name of *Gelatinous Arthritis*, and by its long duration, and long period of convalescence after operation, permits us to see one reason why so many surgeons have, in these joint affections, preferred the ready method of amputation to the more conservative but more tedious mode of treatment by excision.

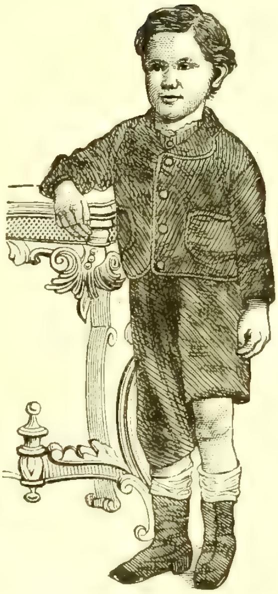
Gelatinous Arthritis of three years' duration; Excision; Recovery with Useful Limb; Recontraction after several years; Re-excision; Second recovery with Useful Limb.—Rose U., eight years of age, was admitted to the Episcopal Hospital on March 25, 1874, suffering from gelatinous arthritis of the right knee, the disease having existed since her fifth year. She had been for a time a patient in the Orthopædic Hospital. Excision by the usual transverse incision was performed on March 30, no trace whatever being found of the semilunar cartilages, and the synovial structures being found in a "gelatiniform" condition, though the bones, in spite of the long duration of the disease, were but slightly affected. Three vessels were secured with ligatures, the wound was closed with lead wire sutures and dressed with oiled lint, and the limb was placed on the customary splint. By the system of rotation which prevails in the Episcopal Hospital, the patient passed out of my hands shortly after the operation, and I did not see her again, except casually, until I resumed the care of the wards in January, 1875. At that time the excision wound had cicatrized, and the resected bones were firmly united, but a number of sinuses surrounded the limb, the soft parts were much thickened and infiltrated, and the scar presented a remarkable, prominent, keloid-like appearance.

On January 4, I removed the bracketed splint, upon which the limb had hitherto been kept, and substituted a moulded, pasteboard gutter, covering the site of the exsected joint with compound iodine ointment, and a soap-plaster and firm bandage. Under this treatment the swelling rapidly subsided, and the keloid-like appearance of the cicatrix disappeared, and by the middle of the month the patient walked readily with crutches. In April both splint and crutches were dispensed with, and from that time Rose walked, and even ran, without any artificial assistance. She was kept in Hospital some months longer, as a few sinuses persisted, but was ultimately discharged with apparently firm bony union, and a perfectly straight leg. I now lost sight of this patient for over seven years, but in October, 1882, she applied to me at the University Hospital, with her knee contracted to a right angle, and immovable. The contraction she said had been coming on for about two years. Shortly after this date I operated again, by sawing out a wedge-shaped block from the angle of the limb, as in Dr. Gurdon Buck's method. The result of the re-excision was favorable, and Rose has now again (October, 1883), a straight and firm limb, and walks without artificial aid.

In my next case, which was also one of gelatinous arthritis, the operation was followed by profuse secondary hemorrhage on the thirteenth day; notwithstanding which the patient made an excellent and even rapid recovery.

Excision of Knee-Joint for Gelatinous Arthritis; Secondary Hemorrhage; Recovery with Useful Limb.—James M., six years of age, entered the Episcopal Hospital on May 7, 1875, suffering from gelatinous arthritis of the left knee, following an injury

Fig. 743.



which had been received one year before. The joint was much swollen, and the limb was useless, but there was not much pain, and, as customary in this variety of arthritis, not much impairment of motion.

Excision was performed in the ordinary way on May 13, six or seven ligatures being required, and the limb being subsequently dressed as in my other cases. On the eighth day, all the ligatures and sutures were away, the wound was mostly united, the limb was in excellent position, and everything promised an uninterrupted recovery. On the thirteenth day (May 26), without any obvious cause, profuse secondary hemorrhage occurred, the wound being stuffed with clots, and the dressings saturated with blood. Knowing that no large vessel had been divided in the operation, and unwilling to interfere unnecessarily with the progress of repair, I did not open the wound, but contented myself with applying an ice-bag and elevating the limb. The bleeding did not recur, the clots which had formed, gradually became disintegrated, and were spontaneously discharged, and the wound healed by granulation. In July the patient could walk with the support of a simple pasteboard splint, and in August even this was dispensed with, bony union of the resected bones being by this time completed. The patient was retained in hospital until October, 1875, a photograph, from which the annexed illustration (Fig. 743) is taken, having been obtained before his discharge. He was seen shortly afterwards in the neighborhood of the hospital, taking an active part in a stone fight with other boys.

In the next case, one of excision for gelatinous arthritis, in an adult, I was obliged to abandon the attempt to preserve the limb; amputation of the thigh was adopted as the only means of saving life, and was followed by rapid convalescence.

Excision of the Knee for Gelatinous Arthritis of three years' standing; Recurrence of Caries; Amputation; Recovery.—J. W., an Englishman, 28 years of age, and a machinist by occupation, was admitted to the Episcopal Hospital on January 27, 1876, suffering from disease of the left knee-joint of three years' duration, but which had incapacitated him from going about for only a few months. The case was recognized as one of gelatinous arthritis in an advanced stage, the joint being much swollen and misshaped, doughy, and fluctuating; it was painful and tender to the touch, with starting pains at night, and relaxation and manifest disorganization of the ligamentous structures. Extension was applied by means of a weight and pulley, and the limb placed at rest in a long fracture-box, while the joint itself was dressed with various topical remedies of a soothing and resolvent character, tonics, and a moderate amount of stimulus, being at the same time administered internally. During February, it became evident that intra-articular suppuration had occurred, and the joint was accordingly tapped with an exploring trocar, giving exit to a considerable quantity of partially purulent fluid.

Although some relief was afforded by the various measures above referred to, no permanent improvement occurred, and in the early part of March, as the patient's general health was failing, it became obvious that more radical interference was required. Excision was determined on, rather than amputation, because the morbid action in the joint was strictly confined within the limits of the articulation, and because there was at least no positive evidence of the existence of any visceral complication.

Accordingly, on March 9, 1876, the patient having been brought under the influence of ether, I excised the joint in the usual way, making a single transverse incision below the patella. The operation presented no peculiar features except that it was attended with unusually free bleeding, requiring the application of eight or nine ligatures. The ligamentous and synovial tissues were found, as had been anticipated, reduced to a gelatiniform condition, the semilunar cartilages having almost disappeared, the articular cartilage of the femur being widely eroded, and the femoral condyles deeply carious; a patch of caries, too, existed on the patella, but the tibia was healthy. The joint contained pus, and a large suppurating bursa extended upwards beneath the tendon of the quadriceps extensor femoris. The edges of the wound were approximated with iron-wire sutures, the line of incision was dressed with oiled lint, and the whole limb was firmly fixed in the bracketed wire splint, previously well padded with tow, and secured with broad strips of adhesive plaster and bandages. The patient was then restored to his bed, and the resected limb, splint and all, supported on a pillow, in a large, loose fracture-box.

A good deal of constitutional disturbance followed the operation, but, upon the whole, the patient's progress was for some weeks satisfactory. I find a note, on March 20, that all the sutures and ligatures were away, the wound united, the discharge lessening, and union of the resected bone-surfaces beginning. The pulse-rate, however, kept up to 120 or more, and the patient continued, as he had been since the operation, fretful and desponding. During April, it became evident that caries had recurred at the inner side of the limb, and in May it was noted that abscesses had formed above and below, that the discharge was increasing, and that the bones were less firmly united than they had been a fortnight before; with the approach of warm weather, too, the patient's strength began to fail, and we were forced to see that a further attempt to save the limb would seriously endanger the patient's life.

On May 19, therefore, a little more than ten weeks after the date of excision, I amputated at the junction of the middle and lower thirds of the thigh, cutting anterior and posterior flaps, the former from without inwards, and the latter by transfixion. From the time of this operation the patient convalesced without a single bad symptom; he was as cheerful and happy without his leg as he had been gloomy and discontented with it. The flaps united by adhesion; the last ligature dropped on the fourteenth day; on the fifteenth the patient sat up; and on the twenty-fifth the stump was sufficiently solid for him to begin to walk with crutches. On July 3, he was made an out-patient, and has been frequently seen since, in excellent health and spirits; several osseous spicula have come away from his stump, in which one sinus still persisted in January, 1877.

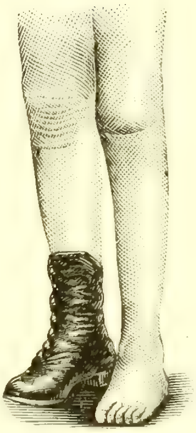
Could the operator invariably recognize in advance those cases in which the powers of nature were, and those in which they were not, likely to prove sufficient for the process of repair after excision, this department of surgery would approximate to the rank of an exact science, and such a history as that just recorded would never have to be written; but, as the matter stands at present, it is surely the surgeon's duty to give the patient the benefit of the doubt, and, if amputation is not manifestly called for, to attempt the conservative operation of excision; knowing that, if necessary, the limb can be subsequently removed with comparatively little risk to life—less, indeed, according to Pénière's and Culbertson's statistics, than attends amputation of the thigh for disease in general.

Excision of Knee for Partial Anchylosis with Arthritis of nineteen years' duration; Recovery with Useful Limb.—The subject of this case, Kate H., twenty-six years of age, was sent to me by Dr. W. H. Bunn, of Philadelphia, and was admitted to the Episcopal Hospital on March 20, 1876. She had suffered more or less from disease of the left knee since she had been seven years old, the last attack having kept her in bed six months, and the joint at the time of her admission being very painful and tender, swollen, and somewhat contracted; the tibia was displaced backwards, and distinct grating was elicited on moving the articulation, while the characteristic "jumping" or "starting" pains at night showed the erosion of the articular cartilages, and the implication of the underlying bone. The patient's general condition was, however, satisfactory, and there was no evidence of the presence of any visceral disease.

After consultation with my colleagues, I excised the joint in the usual way on March 24, securing the limb after the operation in the bracketed wire splint, and placing the whole on a pillow and in a large fracture-box. The condition of the joint, when it was laid open, amply justified our decision as to the necessity of interference, the semilunar cartilages having entirely, and the crucial ligaments almost, disappeared, the articular cartilages being eroded, and the femoral condyles and tibia being carious. The greater part of the joint was obliterated by the existence of intra-articular adhesions, while in front of the femur there was a portion of synovial membrane which had undergone the gelatiniform change, thus illustrating the fact, which is familiar to surgeons who see many of these cases, that the gelatinous and the ordinary form of arthritis often coexist in the same case, and that, as regards their pathology, they differ in degree rather than in kind.

The convalescence of this patient after the operation was rapid and satisfactory. The wound united by adhesion, except at its extreme corners; the last ligature—only five were employed—dropped on the sixteenth day; the splint was removed for the first time during the sixth week, and, osseous union having occurred, was replaced by a pasteboard gutter about a week later. By the middle of May the patient was allowed to sit up, and in the latter part of the same month began to walk with crutches; in the beginning of June the pasteboard splint was exchanged for a simple soap plaster and bandage, and on July 3, one hundred and one days after the date of operation, the patient was discharged, cured, a photograph, from which the annexed wood-cut (Fig. 744) is taken, having been previously secured. At this time the wound was firmly healed, and the patient could walk without artificial assistance.

Fig. 744.



Result of excision of the knee-joint.

One of the most difficult excisions in its performance, and at the same time one of the most gratifying in its results, that I have ever met with, was that which was briefly related on page 446.

By a curious coincidence, two years afterwards, another lady of about the same age (32 years), and also a school-teacher, while visiting friends in West Chester, heard of the successful result in this case, and, consulting Dr. Massey in regard to her own knee, was by him sent to me. She had suffered from disease of the articulation in early childhood, and when she came under my observation had the joint fixed by bony anchylosis at an angle of less than 90°, so that she could only walk by the aid of a stilt-like support which she wore under her cloak. I operated upon her knee by Buck's method (excision in a block) on April 17, 1879, and she returned to her home in the following September, with a straight and firm limb, which has since constantly increased in usefulness. Her convalescence was delayed by profuse suppuration, and by the occurrence of secondary hemorrhage, without any obvious cause, during the third week after operation.

I have, in all, excised the knee-joint 26 times in 25 patients—one case was an example of re-excision—with 22 recoveries (one of these after amputation), 2 cases not terminated, and only 2 deaths. The particulars of all these cases are briefly included in the following table:—

TABLE SHOWING THE PARTICULARS OF TWENTY-SIX CASES OF EXCISION OF THE KNEE-JOINT FOR DISEASE OF THE ARTICULATION.

No.	Sex and age.	Nature of disease.	Duration of disease before operation.	Result; duration of treatment after operation.	Remarks.
1	Male, 10	Anchylosis and arthritis	Four years	Recovered; 5 months	Useful limb.
2	Female, 11	Arthritis	Six years	Recovered; 1 year	Useful limb.
3	Male, 18	Arthritis and abscess	One year	Recovered; 16 months	Useful limb.
4	Male, 9	Arthritis and abscess	Three months	Recovered; 4½ months	Useful limb.
5	Female, 9	Arthritis and anchylosis	Two years	Recovered; 20 months	Useful limb.
6	Female, 8	Gelatinous arthritis	Three years	Recovered; 13 months	Useful limb. See No. 24.
7	Male, 5	Gelatinous arthritis	Over two years	Recovered; 6 months	Useful limb.
8	Male, 6	Gelatinous arthritis	One year	Recovered; 5 months	Useful limb.
9	Male, 5	Gelatinous arthritis	About two years	Recovered; 1 year	Useful limb.
10	Male, 7	Anchylosis and arthritis	Two years	Recovered; 9 months	Useful limb.
11	Male, 28	Gelatinous arthritis	Three years	Recovered; 6 months	Amputation.
12	Female, 26	Arthritis and anchylosis	Nineteen years	Recovered; 3½ months	Useful limb.
13	Female, 30	Arthritis and anchylosis	Twenty-three yrs	Recovered; 6 months	Useful limb.
14	Male, 9	Arthritis and anchylosis	Over one year	Recovered; 15 months	Useful limb.
15	Female, 32	Anchylosis	Many years	Recovered; 5 months	Useful limb.
16	Female, 9	Gelatinous arthritis	Four years	Recovered; 10 months	Useful limb.
17	Male, 13	Arthritis and anchylosis	Six years	Recovered; 6 months	Useful limb.
18	Female, 6	Gelatinous arthritis	Four years	Died; 4 weeks	Death from septicæmic pneumonia, etc.
19	Male, 9	Gelatinous arthritis	Nearly two years	Recovered; 1½ years	Useful limb.
20	Male, 17	Anchylosis, etc.	Several years	Recovered; 3 months	Useful limb.
21	Male, 5	Gelatinous arthritis	Two years	Recovered; 10 months	
22	Female, 6	Anchylosis, etc.	One year	Died; 10 days	Death from double pneumonia.
23	Male, 6	Gelatinous arthritis	One year	Recovered; 1 year	Useful limb.
24	Female, 17	Anchylosis	Seven years	Recovered; 1 year	Useful limb. Re-excision; See No. 6.
25	Male, 14	Gelatinous arthritis	Two-and-a-half [years	Still under treatment	Doing well.
26	Male, 40	Syphilitic arthritis	Several years	Still under treatment	Doing well.

In considering the applicability of the operation of excision in the treatment of disease of the knee-joint, I may put what I have to say in the form of answers to the following questions:—

(1) When should the surgeon abandon expectant measures in the treatment of knee-joint disease, and what may be considered the indications for a resort to operation?

(2) Operative interference having been resolved upon, how shall the surgeon decide between excision and amputation?

In order to give an intelligent answer to the first question, it is necessary to consider what are the prospects of recovery without operation, and what the condition of the limb is likely to be if such a recovery can be obtained. To no class of diseases is the maxim "obsta principiis" more applicable than to joint-affections, for if carefully treated from their beginning they seldom terminate badly. Of course I am not speaking now of *wounds* of joints, for these are always very serious injuries, and too often end, even under the most favorable circumstances, in the loss of life or limb. But, in their early stages, inflammatory affections of even the largest joints, whether following upon contusions or sprains, or of non-traumatic origin, are usually quite amenable to treatment. No doubt in some few cases there is such a constitutional predisposition to destructive bone-and-joint disease, that from a very slight cause very serious consequences may ensue: thus, many years ago, a boy was under my care, who, from a fall on the ice, received a contusion of the elbow, followed in a few days by suppuration of that joint, and then by acute necrosis of the humerus and pyarthrosis of the shoulder, and whose life was barely saved by amputation at the shoulder-joint; but such cases are happily exceptional, and in a large majority of instances, if the patient can be at once put under careful and judicious treatment, a favorable result will follow.

But, unfortunately, these cases at first seem so trivial that they are too commonly neglected until the disease is far advanced. And so it happens that in many—perhaps half—of the cases of joint disease which are brought to our hospitals, the time has already past during which treatment, to be most efficient, should have been employed. Thus of the 26 cases of knee-excision embraced in my table, in only one had the disease lasted less than one year, the duration in the other cases ranging from one to twenty-three years. I do not deny that in some of these cases recovery might perhaps have been eventually obtained without operation, but what kind of recovery would it have been? We do, indeed, meet men and women hobbling about on crutches, with knees bent, and limbs withered and deformed, and such results may doubtless, in a certain sense, be called spontaneous cures; but what I maintain is that the limbs preserved by expectant treatment in these advanced cases of joint disease, are inferior to the limbs secured by the conservative operation of excision, and little, if any, better than no limbs at all.

I have dwelt upon this point at some length, because I believe that there are still many members of the profession who look upon excision of the knee-joint as a remedy of doubtful excellence, and who think that cases not bad enough for amputation should not be operated on at all.

In deciding whether an operation is required in any particular case of knee-joint disease, the surgeon must consider the age and general condition of the patient, the duration of the affection, and the stage to which it has advanced.

As regards *age*, no operation should as a rule be performed in cases occurring in very young children. No doubt in some rare instances the life of the patient may be in danger from the exhaustion produced by an inflamed and suppurating knee-joint, and in such cases the surgeon must choose the least of two evils, and remove the source of irritation by amputating the limb. But in the large majority of cases it is better to temporize, to put the part in as good a position as possible by straightening the limb, dividing tendons if necessary, and, as it were, patching up the joint, until the patient reaches an age when operative interference can be adopted with a better prospect of success. Excision of the knee is not a very successful operation in quite young children; these suffer more from confinement than those who are older, the restraint necessary during the after-treatment is more irksome to them, and they are, I think, more liable to the insidious development of tuberculous and other constitutional diseases. My own rule has been to postpone operation until the child has attained to at least the age of five—better nine or ten—years, and those cases which I have seen operated on by others at an earlier period of life, have usually done badly. Again, in persons past the middle age, unless amputation is positively required to rescue the patient from impending death, it is better as a rule to avoid operation. The mortality after excision is so great in these cases that prudent surgery would, it seems to me, under such circumstances, dictate rather to take the chances of a cure by the effects of nature, than to attempt to hasten recovery by operation.

The following table, compiled from Culbertson's figures, shows in a very satisfactory manner the mortality of knee-joint excision at different ages:—

TABLE SHOWING RESULTS OF EXCISION OF THE KNEE FOR DISEASE AT DIFFERENT AGES.

Age.	Total.	Recovered.	Died.	Result not determined.	Mortality per cent. of terminated cases.
Under 5 years	19	11	7	1	38.9
Between 5 and 10 years . .	106	88	17	1	16.2
" 10 " 15 " . .	99	81	18	...	17.2
" 15 " 20 " . .	84	58	25	1	30.1
" 20 " 25 " . .	67	40	26	1	39.4
" 25 " 30 " . .	55	34	20	1	37.0
" 30 " 40 " . .	65	38	27	...	41.5
Over 40 years	19	9	10	...	52.6
Age not stated	89	60	28	1	31.8
Aggregates . . .	603	419	178	6	29.8

The most favorable age for excision of the knee, as regards life, is from five to ten, but there is more risk then of consecutive shortening than at a later age, and the occurrence of bony union is obtained with more difficulty; hence the period of puberty is upon the whole that which may be considered to furnish the most favorable results.

In considering the *general condition* of the patient, when the question of operation arises, the surgeon must remember that these are essentially chronic cases, and that there can seldom be any justification for haste in operating, when by delaying a few weeks, or even months, the patient may be placed by constitutional and hygienic treatment in a more favorable condition to sustain whatever operation may be necessary. The presence of visceral disease, whether of the lungs or abdominal organs, must usually be considered a positive contraindication to excision, and under these circumstances, unless the local condition of the knee render amputation imperative, no operation should, as a rule, be performed. On the other hand, if the patient presents no evidence of visceral disease, and the general health seems to be directly suffering from the irritation arising from the diseased joint, the timely removal of the source of disturbance either by excision or amputation may prove the starting-point of rapid convalescence.

The *duration of the malady* must be considered by the surgeon in any case of knee-joint disease before deciding upon the propriety of an operation. I am not one of those who hold that a surgeon is bound invariably to wait a certain number of weeks or months to give, as is often said, a "fair trial" to other treatment before recommending an operation, for I believe that a thorough knowledge of the course and natural history of the disease will often enable him to say at once whether any particular case can or cannot be benefited by expectant measures. In their early stages, as I have before remarked, these knee-joint affections are quite amenable to treatment, and hence, putting out of the question some few cases of very rapid articular disorganization in which amputation is required, a judicious surgeon would in cases of recent origin endeavor to obtain, and would probably succeed in obtaining, a natural cure by placing the joint in good position, and at rest, by relieving intra-articular pressure by the use of continuous extension, and by combating the morbid process by careful constitutional and local treatment.

In a recent case, then, an operation can seldom be required; on the other hand, if the disease has lasted many years, the process of natural cure (such as it is) being pretty well advanced, and the patient perhaps past the age at which excision would be likely to prove successful, the prudent surgeon will usually decline an operation, and content himself with straightening the limb either by gradual or immediate extension, then placing it at rest in a suitable splint, and simply aiding nature to complete the cure by anchylosis. But in the intermediate cases (and, as already remarked, these constitute a large proportion of those which come under the care of the hospital surgeon), when the disease has already lasted many months or even several years, and when from careful examination of the joint the surgeon is satisfied that its functions are permanently abolished, an operation may often be properly recommended as a means both of preventing suffering and of restoring the patient to active life more promptly than can be done by any other mode of treatment.

Even more worthy of consideration than the duration of the disease, is the *stage to which it has advanced;* and it is here to be remembered that the course of these joint-affections varies much in different cases. No operation is, as a rule, justifiable as long as the disease is limited to the synovial membrane, no matter how long the patient may have been affected; no prudent surgeon would recommend either excision or amputation in a case of mere hydrarthrosis. Nor even in a case in which all the tissues of the joint are evidently implicated should an operation be hastily recommended, as long as the integrity of the parts is maintained, and a hope remains that by subduing the inflammation the usefulness of the articulation may be preserved. But when the relaxed condition of the joint, and the occurrence of consecutive dislocation, show that the crucial ligaments and semilunar cartilages have disappeared; when the limb is contracted and helpless, and the patient gives a history of repeated relapses from comparatively slight injuries; or, on the other hand, when the doughy, semi-elastic character of the swelling shows the existence of gelatinous arthritis (the typical "white swelling" of the older writers), an operation may be properly resorted to even though the limb be at the time in a quiet condition. When in addition the joint is in a state of suppuration, and still more if there be caries of the articular surfaces, an operation may be considered (other things being favorable) as almost imperative.

In saying this I am not ignoring the fact that Mr. Haward and other British surgeons have applied mineral acids, and Mr. Fitzpatrick, of Dublin, the *potassa cum calce*, to the interior of diseased knee-joints, and have recommended these modes of treatment as substitutes for excision, as has Mr. Wright the laying open of the joint and scraping away the diseased structures. But the results of these methods have not been uniformly favorable, and excision has been found so satisfactory in my own hands that I have not felt tempted to abandon a tried and proved operation, for a procedure which at least has not as yet been shown to be an improvement.

It may be observed that in cases of *gelatinous arthritis*, an operation may be properly recommended at a comparatively early period; the reason for this is that in the gelatinous form of the disease there is commonly no tendency to a spontaneous recovery, and though in private practice, among the more wealthy classes, such a case may occasionally be brought to a favorable termination, in the class of patients met with in hospitals, a recovery without operation may practically be considered as out of the question.

The answer to the second question has of necessity been to a great degree anticipated in considering the first. The choice between excision and amputation must largely depend on the surgeon's belief as to the relative gravity of the two operations, and upon this point I have no hesitation in saying that I regard excision as a much more serious operation than the other. This is not a question to be decided by statistics (though I believe that if the comparison could be fairly made the result would be found in favor of amputation), for excision is habitually performed in selected cases, while all the rest are reserved for amputation.

And this is, indeed, the true point of view from which to look upon the question. The surgeon's first thought should undoubtedly be of excision—for when successful the result is immeasurably superior to the best result of amputation—but before deciding upon this operation he should weigh well all the circumstances of the case, the age and constitutional condition of the patient, the extent to which the bones entering into the articulation are affected, and the facilities which will be afforded by the patient's surroundings for conducting the after-treatment (often prolonged and wearisome) to a successful issue. If then the patient be neither too young nor too old, if there be no evidence of visceral complication, if the disease be sufficiently limited to allow of its entire removal without taking away so much bone as would materially impair the usefulness of the limb, and if the patient be so situated that the question of the time required for recovery is of secondary importance, the surgeon should choose excision, and by doing so will probably succeed in preserving for his patient a limb better than any artificial substitute, and in most cases better than could be obtained by the unaided powers of nature; under opposite circumstances, provided that the case is bad enough to require any operation, amputation should be resorted to, and the surgeon who employs it under such, and only under such, circumstances, will not have occasion to regret his decision.

Comparatively a successful operation when performed for chronic joint-disease, excision of the knee is a very grave procedure in cases of *wound* of the articulation, and is so fatal in cases of *gunshot injury* that it may fairly be questioned whether it should not be banished from military surgery. The figures bearing upon this point may be seen in the following table, compiled from the statistics of Gurlt and Culbertson:—

TABLE SHOWING RESULTS OF EXCISION OF THE KNEE FOR INJURY AND FOR DISEASE.

Nature of case.	Total.	Recovered.	Died.	Result not determined.	Mortality per cent. of terminated cases.
Gunshot wound	146	33	111	2	77.1
Other injury	28	17	11	...	39.3
Disease	603	419	178	6	29.8
Aggregates . . .	777	469	300	8	39.0

The result as to the *ultimate usefulness* of the preserved limb, in cases of knee-excision, is, in most cases, very satisfactory. Of the 9 cases of excision for gunshot wound, in Gurlt's table,[1] the "end-result" was "very good" in 5, and "good" in 3; while the 17 recoveries after excision for other forms of injury, tabulated by Culbertson, gave 3 "perfect," and 11 "useful" limbs. My own list of 22 recoveries has given one amputation, one re-excision, and one doubtful case, leaving 19 in which the utility of the limb was assured, the permanence of the benefit derived having, in many of these cases, been verified years after the operation. The following summary shows the ultimate result in Culbertson's 603 cases of excision for disease:—

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[1] See page 470.

Recovered without further operation	354 or 58.7	per cent.
Recovered with useful limbs	246 or 40.8	"
Died without further operation	166 or 27.5	"
Result undetermined without further operation	5 or 0.8	"
Recovered after subsequent amputation	65 or 10.8	"
Died after subsequent amputation	12 or 2.0	"
Result undetermined after subsequent amputation	1 or 0.2	"
Death-rate of terminated cases in which no further operation was performed	31.9	"

The *antiseptic method* is extolled by Ollier[1] in its application to excision of the knee, and he records 7 cases treated with antiseptic precautions, of which 6 ended in recovery, and 1 in death—apparently as the result of carbolic-acid poisoning. These results are not as good as those which I have myself obtained without any attempt to enforce Listerian measures. Ollier lays great stress upon the importance of preserving the periosteum and joint-capsule, making a small H-shaped incision in order to expose the bones, and additional lateral incisions for drainage. He takes particular pains not to divide the lateral ligaments, and, removing the patella, employs sutures not only to keep the sawn bones in apposition, but also to unite the tendon of the quadriceps femoris above to the ligamentum patellæ below. In traumatic cases, he advises that a single, longitudinal, median incision should be adopted, dividing the patella, which, under these circumstances, should not be removed. He attributes the first employment of the transverse section of the patella, as practised by Golding Bird, to Volkmann.

EXCISION OF THE PATELLA.—What is sometimes called *partial excision* of the patella—that is, gouging away its external surface—is an operation attended by no particular risk, and may be resorted to without hesitation in cases of caries or superficial necrosis affecting this bone; I have myself performed such an operation, in a case of syphilitic necrosis, with a favorable result. But when the *whole thickness* of the bone is removed, the knee-joint is necessarily implicated,[2] and the danger correspondingly increased. The operation may be required in cases of compound fracture, especially from gunshot injury, or of caries or necrosis. The bone may be conveniently exposed by means of a crucial incision. Heyfelder and Bœckel tabulate twelve cases, to which may be added others recorded by Knode, Wood, and Gay, and two cases referred to by Prof. Agnew as having occurred at the Pennsylvania Hospital. Of the whole 17 cases, 3 are said to have proved fatal, and 3 to have required subsequent amputation, while 11 terminated successfully.

RESECTION OF THE BONES OF THE LEG.—Resection of the *tibia* may be required in cases of irreducible compound fracture, ununited fracture, or fracture united with great deformity; and complete excision of the shaft of the bone has been successfully practised by various surgeons in cases of acute necrosis following subperiosteal abscess. The bone may be readily exposed by a longitudinal incision over its anterior, subcutaneous surface, supplemented, if necessary, by a short transverse cut. When the whole thickness of the tibia is resected, a corresponding disk must ordinarily be removed from the fibula, so as to allow union to occur without altering the axis of the limb. In cases of acute necrosis, however, the fibula is not interfered with, and the tibial shaft is removed subperiosteally by dividing it with a chain-saw, and then wrenching either end from its epiphyseal attachment with the lion-jawed forceps.

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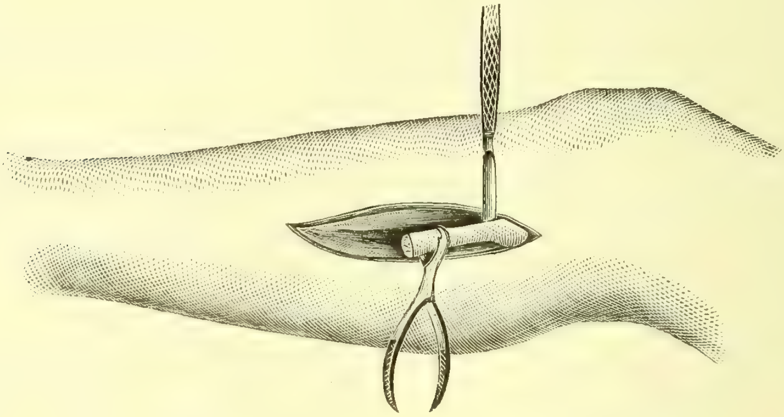
[1] Revue de Chirurgie, 10 Avril et 10 Mai, 1883.

[2] Bœckel, of Strasbourg, quotes a case in which Held removed the whole patella, in a state of necrosis, without opening the joint, which was walled off by a layer of granulations; such an operation is practically little more than a sequestrotomy.

The *fibula* may be resected with much less hesitation than the tibia, and, indeed, provided that the external malleolus is preserved, it may be entirely removed without materially impairing the usefulness of the limb. If the malleolus be lost, the foot is apt to become everted. A single longitudinal incision on the outer side of the limb, suffices to expose the bone, which is then divided with a chain-saw, and carefully separated from its attachments, the periosteum being, if possible, preserved. In excising the upper end of the fibula (Fig. 745) there is some little risk of opening the knee-joint, which, according to Lenoir, communicates with the tibio-fibular articulation once in ten times.

Fig. 745.



Resection of upper end of fibula.

The results of these operations, except in cases of compound fracture, are quite satisfactory. On page 447 will be found a brief reference to a case of acquired deformity of the leg which I succeeded in remedying by a resection of both bones. The following table, borrowed from Heyfelder and Bœckel,[1] shows the result in 125 cases of leg-excision for various causes:—

TABLE SHOWING RESULTS OF EXCISION OF THE BONES OF THE LEG FOR VARIOUS CONDITIONS.

Nature of case.	Number of cases.	Recovered.	Complete success.	Incomplete success.	Died.
Fracture	65	47	43	4	18
False joint	11	11	10	1	0
Deformity of callus	16	15	14	1	1
Incurvation	11	11	11	0	0
Organic disease	22	20	19	1	2
Aggregates . . .	125	104	97	7	21

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[1] Op. cit., p. 22.

The next table shows the results of 387 cases in which resection of the leg-bones was performed during the late American war.[1]

TABLE SHOWING RESULTS OF EXCISION OF THE BONES OF THE LEG FOR GUNSHOT INJURY.

Period of operation.	Total.	Recovered.	Died.	Undetermined.	Mortality per cent. of terminated cases.
Primary	215	148	67	...	31.1
Intermediate	87	58	29	...	33.3
Secondary	50	42	8	...	16.0
Unknown	35	27	4	4	12.9
Aggregates	387	275	108	4	28.2

The results in the treatment of compound fractures are thus seen to be far from encouraging; the mortality in civil practice being 27.4 per cent. and that in army-surgery 28.2 per cent., somewhat less, it is true, than the mortality of amputation in this locality, but proportionately higher when it is remembered that resection is an operation reserved for selected cases—for such as are considered to offer a prospect of preserving both life and limb.

EXCISION OF THE ANKLE.—Strictly speaking, this term should be limited to an operation involving the removal, partial or complete, of the tibio-tarsal articulation, and no more; but it is habitually applied by surgical writers to other and more extensive operations as well, to all ankle-joint excisions, in fact, even if supplemented by removal of the whole astragalus, or even of more distant bones.

First performed by the elder Moreau, in 1792, this operation has never acquired great popularity at the hands of surgeons generally, many thinking it better, in cases requiring any interference, to amputate by Syme's or by Pirogoff's method. But while the stumps afforded by these procedures are most serviceable, they do not equal, either in appearance or in usefulness, the member preserved by a successful excision, and hence, in all suitable cases, the latter operation should, I think, be given the preference. It may be practised in cases of compound fracture or dislocation, as well as of chronic disease of the articulation.

Excision of the ankle-joint may be performed by means of two lateral incisions, one behind either malleolus, or, which I consider preferable, by means of a semilunar incision, made to pass around the lower border of the outer malleolus, and then continued longitudinally in the line of the fibula. (Fig. 746.) The anterior portion of this wound should not be prolonged so far as to risk the division of either the extensor tendons or the dorsal artery of the foot. The peroneal tendons having been severed, it is convenient, before going further, to remove the lower end of the fibula, which may be done either with cutting pliers or with a small saw. Polaillon divides the fibula with a chain-saw above the malleolus, leaving the latter attached to the bones of the foot, but there are some advantages in the ordinary method, as allowing more thorough examination of the astragalus. In traumatic cases, a partial excision, involving only the articulating extremities of the tibia and fibula, will often be sufficient, and in cases of disease, if the astragalus be but slightly affected, it will be enough to remove its upper surface with saw or cutting pliers, and then to apply the gouge and osteotrite to any softened or carious patches that may be found remaining. But under other circumstances the astragalus should be removed entire. The surgeon next turns the foot inward, and, having carefully cleared the lower end of the tibia with the probe-pointed knife, cuts away the inner malleolus with strong forceps, and then removes as much of the tibia as may be thought desirable with the chain-saw, or, which I think preferable, as rendering the operation easier, makes a second, short incision on the inner side of the limb, and then divides the tibia with a narrow-bladed saw, passed directly across from one side to the other.

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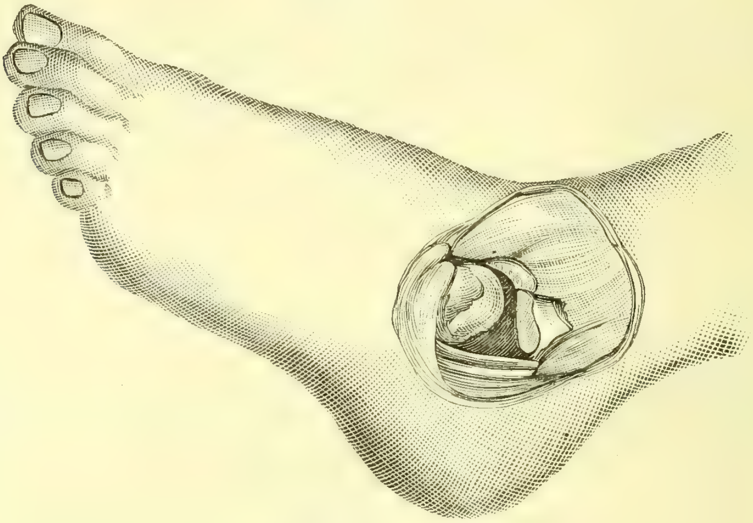
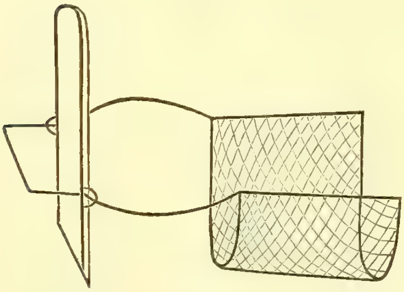
[1] Medical and Surgical History, etc., Third Surgical Volume, page 875.

Fig. 746.



Excision of the ankle-joint.

Fig. 747.



Bracketed wire-splint for after-treatment of excisions of the ankle-joint.

During the after-treatment of ankle-joint excision, the limb may be kept in a fracture-box, or, which I prefer, in a bracketed wire splint such as is shown in Fig. 747. The foot must be kept well supported, lest a condition of acquired talipes equinus result. Fig. 748 illustrates the result in a case of partial excision of the ankle for compound fracture and dislocation, done in my wards at the University Hospital by my assistant, Dr. H. R. Wharton. In two cases of chronic disease of the joint, in which I have resorted to complete excision, the patients did well as regarded their local condition, but died some months after the operation from pulmonary tuberculosis.

The *statistics* of ankle-joint excision have been investigated by several writers, including Spillman, Hancock, Poinsot, Grossheim, Gurlt, and Culbertson. The last-named surgeon has collected[1] 124 cases of the operation as performed for *disease*, of which only 10 are known to have terminated fatally. The affection for which the operation was practised was in most cases arthritis or caries, but in some instances necrosis or bony tumor. The results may be seen in the annexed table:—

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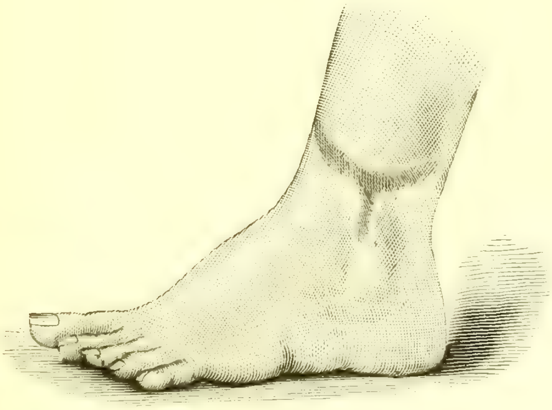
[1] Op. cit., p. 297.

Fig. 748.



Result of ankle-joint excision.

TABLE SHOWING RESULTS OF EXCISION OF THE ANKLE-JOINT FOR DISEASE.

Extent of operation.	Total.	Recovered.	Died.	Result not determined.	Mortality per cent. of terminated cases.
Partial excision	68	57	4	7	6.6
Complete excision	51	45	6	...	11.8
Not stated	5	5	...	...	...
Aggregates . . .	124	107	10	7	8.5

The same author has collected[1] 154 cases of excision for *injury* (other than gunshot wound), and 45 cases in which *gunshot injury* was the cause of operation.[2] The results are shown in the following tables:—

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[1] Ibid.

[2] The operation of excision of the ankle-joint appears to have been introduced into military surgery by Langenbeck, in 1859.

TABLE SHOWING RESULTS OF EXCISION OF THE ANKLE-JOINT FOR INJURY OTHER THAN GUNSHOT WOUND.

Extent of operation.	Total.	Recovered.	Died.	Result not determined.	Mortality per cent. of terminated cases.
Partial excision	147	126	19	2	13.1
Complete excision	7	7	...	...	0.0
Aggregates	154	133	19	2	12.5

TABLE SHOWING RESULTS OF EXCISION OF THE ANKLE-JOINT FOR GUNSHOT INJURY.[1]

Extent of operation.	Total.	Recovered.	Died.	Mortality per cent. of terminated cases.
Partial excision	8	5	3	37.5
Complete excision	19	13	6	31.6
Not stated	18	15	3	16.7
Aggregates	45	33	12	26.7

Grossheim's figures, derived from the Franco-German war, are less flattering: 50 complete excisions gave 26 recoveries, 20 deaths, and 4 undetermined—a mortality of 43.5 per cent.; but, on the other hand, 47 partial excisions (including, however, operations on the tarsal bones) gave 33 recoveries and only 14 deaths, a mortality of but 29.8 per cent. Gurlt's figures embrace 150 cases, with 51 deaths, a mortality of 34 per cent.

The *utility of the limb* preserved by ankle-joint excision has been usually satisfactory. Culbertson tabulates[2] 177 good results out of 196, in which this point was inquired into, a proportion of more than 90 per cent. Gurlt's table of "end-results" in military surgery[3] gives, out of 55 cases, 29 which were "good" or "very good," 23 which were "medium," and only 3 which were really "bad." Stauff, as quoted by Rose, gives the proportion of good results after excision of the ankle as 75 per cent.

EXCISION OF THE ASTRAGALUS.—This operation appears to have been first performed in 1582, by a surgeon of Duisburg, whose case, but not whose name, is recorded by Fabricius Hildanus. The astragalus may be excised when carious or necrosed, or in cases of compound fracture or dislocation. Simple dislocations may also prove an indication for the operation, if the displaced bone cannot be replaced, and if it threaten to produce sloughing by pressure upon the integument.

Excision of the astragalus may be conveniently effected by making a semilunar incision on the anterior and external aspect of the joint (Fig. 749). The removal of the bone may be rendered easier by first cutting across its neck with strong pliers, and then dislodging each fragment in succession with elevator and forceps, using the probe-pointed knife in the deep parts of the wound. In some cases, however, the bone has to be removed piece-meal by means of the gouge.

My personal experience in excision of the astragalus is limited to two cases—one in which I successfully removed the bone, in a state of necrosis, following injury, in a man aged 49; and another in which I removed both

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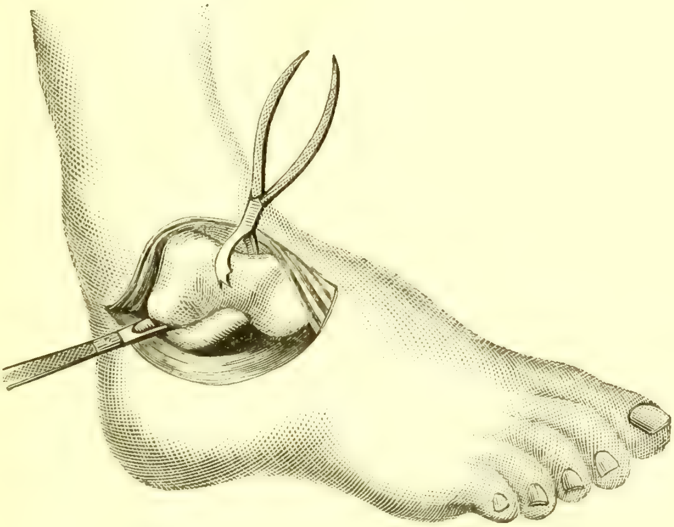
[1] See also tables on pages 444 and 445.

[2] Ibid., page 302.

[3] See page 470.

Fig. 749.



Excision of the astragalus.

astragalus and calcaneum, in an old man, for caries, the patient doing well for several months as regarded his local condition, but ultimately dying from pulmonary phthisis.

The *statistics* of excision of the astragalus have been particularly investigated by Hancock[1] and by Poinsot.[2] The former author has collected 112 cases of total, and 28 of partial excision. Of the complete operations, 79 gave the patients useful limbs, 2 were followed by amputation, and 19 by death, the result in 12 cases not having been ascertained; the mortality of terminated cases was, therefore, 19 per cent. The partial operations gave 18 satisfactory recoveries, 8 less satisfactory or unknown results, and 2 amputations, of which 1 was followed by death. Poinsot's table embraces 144 cases, of which 26, or 18 per cent., terminated fatally.

The *joint between the astragalus and the calcaneum* has been successfully excised by Mr. Annandale.

Excision of the Calcaneum.—This operation, which appears to have been first employed by Monteggia, in 1814, is sometimes required for the relief of caries or necrosis, though in the latter case the extraction of sequestra, and in the former free gouging, or Sédillot's operation of *évidement*, will ordinarily be sufficient.

Various methods have been adopted for the excision of the os calcis. The plan of raising a heel-flap, as in amputation by Syme's method, is objectionable, as leaving a scar on the sole which may interfere with walking. Prof. Erichsen advises the turning down of an elliptic flap, constituted of the plantar tissues, and the formation of lateral, triangular flaps, by carrying a longitudinal incision through the tendo Achillis to meet the first wound. Mr. Holmes's method seems to me preferable. In this mode of performing the operation (Fig. 750), an incision is made on the level of the upper portion of the bone, beginning at the *inner* edge of the tendo Achillis (which it divides), and then passing around the back and *outer* surface of the foot, as far forward as a point midway between the heel and base of the fifth metatarsal bone. From near the anterior end of this incision, a second is made at right angles to it, passing downwards to the beginning of the grooved internal surface of the os calcis. A flap is thus marked out, which includes the cut peronei tendons, and which is then reflected from the bone; the ligaments of the calcaneo-cuboid joint are next divided, when the calcaneum itself can be slightly displaced *inwards*, thus rendering easier the division of the various ligaments which unite it to the astragalus. This having been accomplished, the bone is again twisted *outwards*, and cautiously separated from the soft tissues on its inner side. The calcaneum having been removed, a strip of oiled lint is placed in the cavity which is left, and the limb secured, with the foot at a right angle to the leg, by adjusting an anterior, moulded splint, or the bracketed wire splint recommended for the after-treatment of excision of the ankle.[1]

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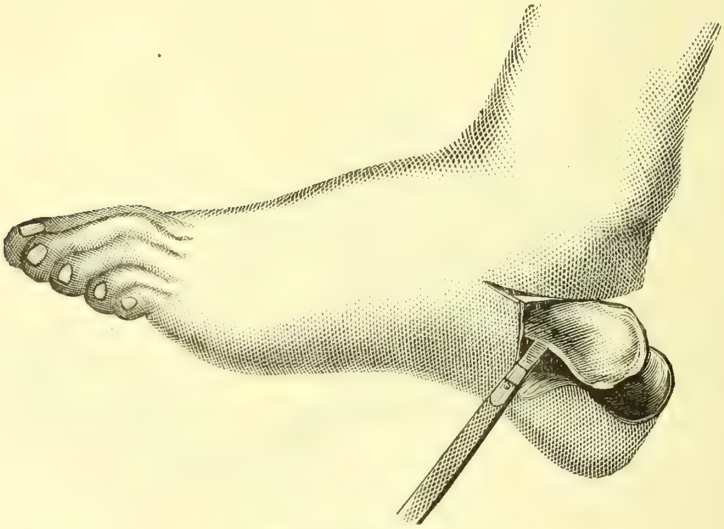
[1] Operative Surgery of the Foot and Ankle-joint, pp. 265–268. London, 1873.

[2] De l'intervention chirurgicale dans les luxations compliquées du coude-pied, pp. 252–271. Paris, 1877.

Fig. 750.



Excision of the calcaneum.

Southam, of Liverpool, and Lund, of Manchester, have still further simplified the operation by making but a single external incision, beginning as in Holmes's method, and carried forward to a point midway between the tip of the malleolus and the projection of the fifth metatarsal bone.

Ollier's method consists in making an incision on the *outer* side of the tendo Achillis, extending from a point nearly one inch above the level of the tip of the external malleolus to the external tuberosity of the calcaneum; a second incision passes from the lower end of the first, along the outer side of the foot, to a point half an inch above and in front of the base of the fifth metatarsal. These incisions are next deepened through the calcaneal periosteum, this membrane being separated, with the overlying tendons, from the bone, which is then seized and extracted after division of its astragaloid attachments. The tendo Achillis is not divided, but its insertion is pushed off together with the periosteum.

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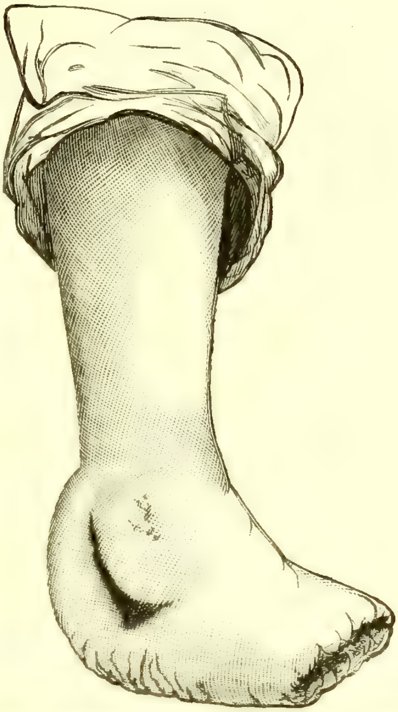
[1] See Fig. 747, page 526.

Fig. 751.



Result of partial excision of os calcis. The patient had also lost his toes by frostbite, but had, nevertheless, a very useful foot.

The subperiosteal method, judging from the report of a discussion upon the subject in the Clinical Society of London, does not appear to have met with much favor at the hands of British surgeons, and, indeed, according to Vincent's[1] statistics, which will be again referred to, it has been followed by a mortality almost the double of that which attends the operation when no attempt to preserve the periosteum is made. In many cases partial excision or free gouging, as by Sédillot's method (*évidement des os*), will prove sufficient, and when applicable should be preferred to extirpation. The result of such an operation, performed by Dr. Wharton in my wards at the University Hospital, for carionecrosis following frostbite, is shown in Fig. 751.

The *statistics* of this operation have been studied by Burrall,[2] of New York, and by Polaillon[3] and Vincent,[4] of Paris. The last-named surgeon has collected 79 cases, to which may be added 6 additional (successful) cases recorded by McGuire and Poore, giving a total of 85, of which but 5 are known to have terminated fatally.

Total number of cases, 85.

Recovered, with useful limb, 55, or 64.7 per cent.
Recovered, but without much use of limb, 5, or 5.9 per cent.
Amputated, 10, or 11.8 per cent.
Died, 5, or 5.9 per cent.
Result undetermined, 10, or 11.8 per cent.

Mortality of sub-periosteal cases (3 out of 23), 13 per cent.

Excision of the Anterior Tarsal Bones.—The tarsal bones, other than the astragalus and os calcis, rarely admit of excision, their diseased conditions, when too far advanced for successful gouging, commonly necessitating amputation. I have, however, myself, on a few occasions, removed one or more bones of the tarsus, the most extensive operation of this kind in my own experience having been the successful excision, in a young child, of the scaphoid, three cuneiforms, and the base of the first metatarsal. Dr. Conner, of Cincinnati, who is the chief apostle of tarsal excisions in this country, has twice successfully removed the *entire tarsus*, and a third operation of the same character, also successful, has been reported by an English surgeon, Mr. H. M. Jones. No positive rules can be given for the excision of the anterior tarsal bones; the lines of incision must be decided by the position of existing sinuses, care being taken of course to avoid unnecessary division of tendons. Dr. Conner[1] has succeeded in collecting no less than 108 cases of tarsal excision of various kinds, the gross mortality having been but a little over 10 per cent.

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[1] De l'ablation du calcaneum, etc. Paris, 1876.
[2] Bellevue and Charity Hospital Reports, p. 91. New York, 1870.
[3] Archives Générales de Médecine, Sept. et Oct. 1869.
[4] Op. cit.

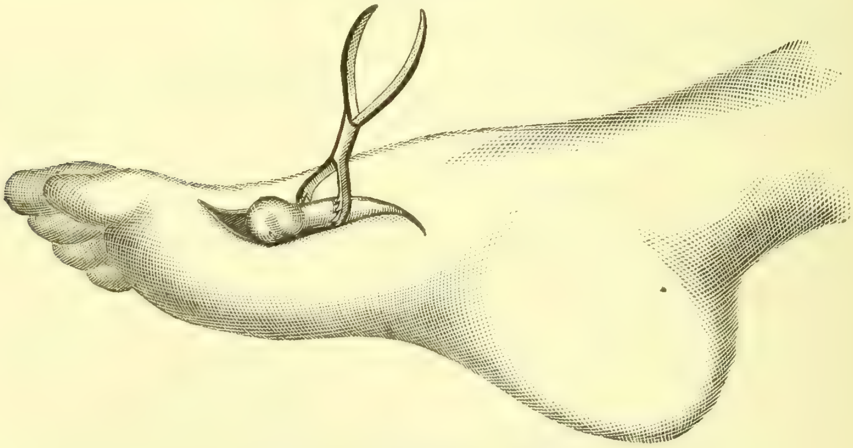
Total number of cases, 108.

Recovered, with very good use of limb, 45, or 41.7 per cent.
Recovered, with good use of limb, 23, or 21.3 per cent.
Recovered, with fair use of limb, 6, or 5.5 per cent.
Recovered, but with failure as regards use of limb, 10, or 9.3 per cent.
Recovered, but uncertain as regards use of limb, 12, or 11.1 per cent.
Result undetermined, 1, or 0.93 per cent.
Died, 11, or 10.18.

Of 31 cases of tarsal excision for gunshot injury, tabulated by Drs. Otis and Huntington,[2] 25 recovered and 5 ended fatally (16.6 per cent.), the result in one instance being undetermined.

Excisions of the Metatarsal Bones.—The bones of the metatarsus may require excision in cases of caries or necrosis, and in some cases of compound fracture, usually as the result of gunshot injury. The lines of incision must be mainly decided by the position of existing sinuses, but it may be said generally that, for the first metatarsal (Fig. 752), the incision should be placed on the inner side of the foot, and for the fifth on the outer side, while the others may be approached from the dorsum. These operations, as those on

Fig. 752.



Excision of metatarsal bone of great toe.

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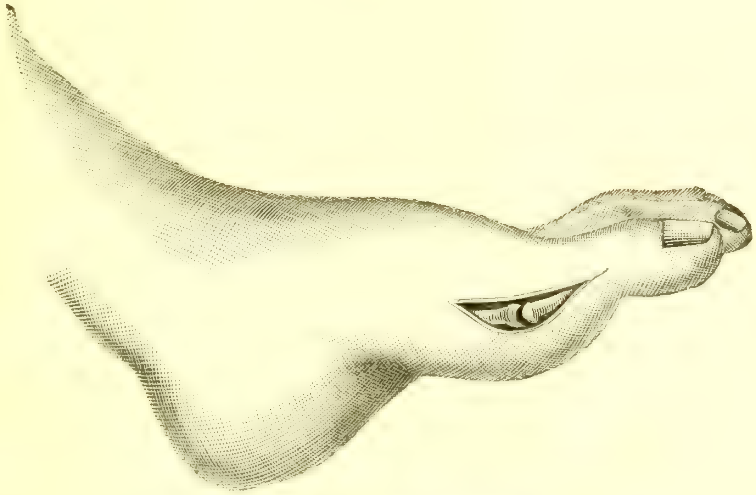
[1] American Journal of the Medical Sciences, Oct. 1883.
[2] Op. cit. Third Surgical Volume, page 622.

the carpus, may be much facilitated by previously rendering the part bloodless by Esmarch's method, the wound after the operation being stuffed with oiled lint, and a compress and firm bandage being applied before the removal of the restraining tube. Of 57 cases of metatarsal excision tabulated by Drs. Otis and Huntington, 46 ended in recovery and 8 in death, the result in 3 being undetermined. The mortality of terminated cases was thus less than 15 per cent.

EXCISION OF THE METATARSO-PHALANGEAL JOINTS. — The articulations between the metatarsal bones and phalanges are seldom excised, injuries or diseases of these joints which require any operation usually demanding amputation. Even in cases of neglected bunion, followed by caries, ablation of the whole toe and head of the metatarsal bone will, I think, commonly be found the best remedy, though complete excision of the joint has under these circumstances been successfully practised by numerous surgeons, including Kramer and the elder Pancoast, and partial excision by others, such as Hueter, Hamilton, Gay, of Buffalo, and A. Rose, who recommends the operation even in cases of simple contraction (*hallux valgus*) without caries. If excision is to be practised, the joint, in the case of the great toe, is to be exposed by a longitudinal incision on the inner side of the foot (Fig. 753), and in the case of the fifth toe by a corresponding wound on the outer side.

Fig. 753.



Excision of metatarso-phalangeal joint of great toe.

EXCISION OF THE PHALANGES OR INTER-PHALANGEAL JOINTS OF THE TOES is not a procedure that can be recommended. Should operative interference be demanded at all, in affections of these parts, amputation should be resorted to.

EXCISION OF THE KNEE-JOINT.

BY

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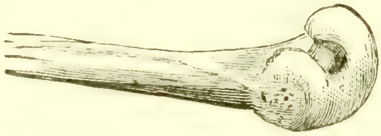
I SHALL in the following pages describe the method of excising the knee-joint which I have myself invariably practised. In all the cases that have come under my own observation I have adopted the single incision in the soft tissues, and have invariably found it sufficient for the purpose.

An incision is made extending from the back part of one condyle of the femur, passing across the front of the joint to the back part of the condyle on the opposite side of the limb. This should be carried below the lower part of the patella, and curved slightly downwards. This incision should divide the ligamentum patellæ and also both lateral ligaments. The joint is thus freely opened; the soft parts, with the patella included, are now reflected upwards, and on flexing the leg upon the thigh, the lower end of the femur will protrude through the wound. The crucial ligaments, if intact, should be divided close to their attachments, and the soft parts freely separated from the intercondyloid notch. In doing this the edge of the knife, guided by the finger, should be kept close to the bone, so as to avoid injury to the popliteal artery, which lies in close proximity to the bone near its centre, and is separated from it only by some fat, occasionally one of the deep lymphatic glands, and some areolar tissue. The whole articular surface can thus at once be brought into view, and its condition observed. It can now be removed with the saw. I have been in the habit for some years past of removing the extremity of the femur with a fine fret-work saw, which I have had adapted to Butcher's frame. By a circular sweep from the front, extending backwards, the operator can take away just so much of the bone as is involved in the disease. If the bone is in process of ulceration, or softened, a second thin slice may be removed. The operator should be careful in making this section to remove an equal length of both condyles, which will enable him to adjust the bones with greater accuracy, and will prevent the tendency to bending of the limb to either the outer or the inner side. By removing the end of the femur after the manner above described, the sawn extremity presents a rounded surface. A thin slice from the face of the bone will, as a

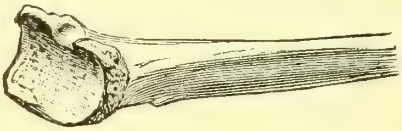
Fig. 754.



Convex surface of lower end of femur after the application of the saw.

general rule, be sufficient; all the disease present, and the entire cartilaginous surface, can be taken away without any unnecessary sacrifice of substance. The importance of this will be at once apparent: if the operation be in a child, the epiphyseal line will not be encroached upon, and the subsequent growth of the bone will not be arrested; if in an adult, the shortening of the limb will scarcely be noticed. The next step in the operation is to clear away the soft parts of the head of the tibia. If, as is so frequently seen, there exist pulpy thickening of the synovial membrane, or much gelatiniform infiltration of the soft parts, this can with advantage be removed. It must be regarded as diseased tissue, is of low vitality, and will, if left, tend to break down, and to delay the subsequent closing of the wound. The head of the tibia having been cleaned, the saw may be applied. In removing the head of the tibia the section should be made from behind forward, rendering it concave. With care, this can be done with such accuracy as to fit it for the reception of the rounded extremity of the femur; a thin slice is usually sufficient, but if, as is sometimes seen, the bone is in a condition of caries, a second slice can be taken away in the same manner.

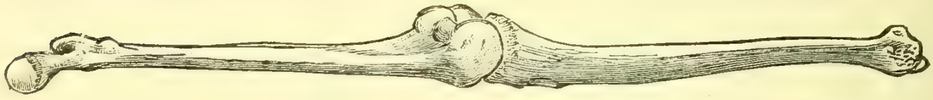
Fig. 755.



Concave surface of the head of the tibia after the application of the saw.

The bones should be accurately adjusted. If it be found that they do not fit nicely, they can be made to do so by taking away another thin slice from either bone, or the rounded extremity of the femur can be reduced with a good, sharp cartilage-knife; thus successive slices can be removed, care being taken not to go beyond the epiphyseal lines. If the case be one in which there has been no previous distortion, such as dislocation backwards of the bones of the leg from neglect of position in the early treatment of the disease, the bones will now come readily together in the straight position. If, on the other hand, difficulty be met with from shortening of the hamstring tendons, these may be divided subcutaneously, or a further section of the bones can be practised. Division of the hamstring tendons should, if possible, be avoided, as it is liable to complicate the case; suppuration is very apt to result, and pus would be likely to follow up the sheaths of the tendons, and give much trouble.

Fig. 756.



The bones fitted together.

The patella has next to be dealt with, and should be removed. Some surgeons have left the patella, taking away a thin slice from its posterior surface; this has been done with the object of giving strength to the union of the bones in front. It is quite possible, under favorable circumstances, for this to occur, but it is quite as likely for the bone to become necrosed, necessitating its removal at a later date, and thereby delaying union. Nature has intended the patella to act as a protection to the front of the joint, and also to give greater leverage power to the quadriceps-extensor muscle; but by removal of the knee-joint the usefulness of the patella is lost, and to leave it behind would serve no good end. Another question of practical interest is whether anything is to be gained by leaving behind the investing sheath of the patella. I have in all my own cases removed the patella, in some cases shelling it out of its bed like the kernel of a nut. I think that leaving the sheath is objectionable, for the reason that nothing is gained by doing so; as it acts as a periosteum, the vessels entering the bones are minute and numerous, and, being in fibrous tissue, great difficulty is experienced in stopping their bleeding; again, a cavity is left, which, after the limb is put up, fills with a clot of blood. In some of my cases the oozing from these vessels has been considerable. In the last three or four cases operated upon I have removed the patella and its investment, and have had much less trouble as regards hemorrhage.

In contemplating the method of section of the bones, as above alluded to, it will be observed that they become locked as it were, the one into the other; in this position they are held by the muscles. As long as the bones remain in this relative position, it will be found that there is no chance of displacement; indeed, I have experienced difficulty in separating them when the patient has slightly recovered from the anæsthetic. After removal of the joint, and of the tags which are sometimes found in the wound, all bleeding points should be secured. This is a matter of great importance to the subsequent success of the case; sometimes the vessels are very minute and very numerous, so that the bleeding is rather a general oozing than a hemorrhage from any vessel that can be ligated. Under these circumstances the application of hot carbolic lotion will be found of advantage. I have on several occasions packed the wound with sponge saturated with hot carbolic lotion, drawn down the flap, and proceeded to apply the splint, and have found on removal of the sponge, for the purpose of closing the wound, that nearly all bleeding had ceased.

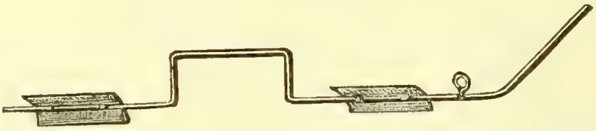
Various forms of apparatus are at the disposal of the surgeon, all having one object, to retain the parts at rest sufficiently long to favor union of the soft parts as well as of the bones. This absolute rest should be combined with freedom from restraint. The apparatus should afford support to the limb, and at the same time should permit change of dressings, and removal of the patient from place to place, as occasion may require, without disturbing the bones.

The apparatus which has seemed to me to answer the purpose better than any other, is that designed by Dr. Patrick Heron Watson, of Edinburgh. There are many advantages to be claimed for its use in dressing the limb after excision of the knee-joint. It is simple in construction, easy of application, and always at hand, and it admits of the application of dressings to the wound without disturbance or removal of the splint, thereby adding materially to the comfort of the patient, and permitting careful cleansing of the part. In speaking of the splints devised by Mr. Butcher and others, Dr. Watson remarks, that he found them "inconvenient and irksome in the last degree to both patient and surgeon." He also draws attention to their unfitness for preventing displacement of the thigh, which is sure to occur "in proportion to the restlessness of the patient." And he says, "the displacements of the thigh I found, as described by every operator, to be of two kinds: rotation in a direction outwards, and abduction with a slight degree of projection forwards. These displacements, I furthermore found, could not be overcome when they once had occurred, without giving great pain, and without the complete re-application of the apparatus."[1]

It is advantageous to fix the limb in the splint before closing the wound. By so doing the surgeon can readily rectify any little displacement of the bones that may occur during the application of the splint, as he has the parts constantly under observation.

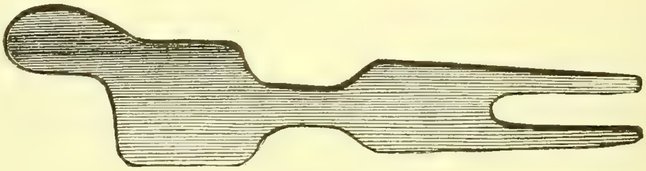
I can fully bear out the claims put forth by Dr. Watson in favor of the apparatus which he has designed for the treatment of excision of the knee-joint, and I cannot do better than quote from his work a description of the apparatus: It consists essentially of two parts: (1) A suspension-rod made of iron or steel, extending from the groin to the extremities of the toes; at the ankle-joint it is bent at an angle to the outline of the foot, and over the situation of the knee it forms a bow or arch. To the upper surface of the rod are riveted one or more hooks, by which the limb can be suspended from the running pulley of a Salter's swinging cradle. As an improvement, I have had attached to the under surface of the bar two square pieces of tin, one situated at the upper part, three inches below the groin, the other over the upper surface of the leg; these give additional firmness, and do not add materially to the weight. They prevent the bar from being displaced or twisted during its application. (2) The second part of the apparatus is made of a Gooch's splint, specially prepared, the laths being somewhat thicker than those ordinarily employed. The splint can be cut out to fit the limb; it should not be too wide, but sufficiently so to surround about two-thirds of the limb's circumference. Laterally, it should be cut out on either side opposite the situation of the wound, leaving a sufficiently broad shelf to give support to the popliteal space. The inferior extremity of the splint is made of the shape of a horse-shoe or stirrup, sufficiently wide to admit the foot, this being supported by the two projecting pieces which pass down on each side of the malleoli. In this way the heel is protected from pressure, and the foot held firmly and amply supported. Dr. Watson gives two forms of back splint, either of which may be selected. In one, at its outer part, the splint is left a little long and rounded, so as to adapt itself to the os innominatum, to

Fig. 757.



Modification of Watson's front splint.

Fig. 758.



Back splint fitted to limb.

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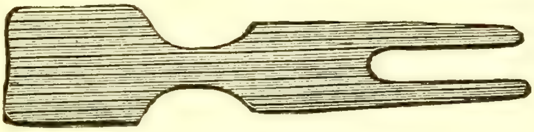
[1] Excision of the Knee-Joint, page 17. Edinburgh, 1867.

which it is attached by adhesive straps. This splint should be well padded with cotton-batting or lint, and covered with gutta-percha tissue. The manner of applying this apparatus is as follows: I shall describe the method pursued in our hospital, which differs in some minor points from that described by Dr. Watson. I have been in the habit of using paraffine, and find that it is quite sufficient to give support, and I think it superior in many respects to the plaster of Paris as recommended by Watson.

Fig. 759.



Back splint without outside piece.

The bones are carefully adjusted, and, while the limb is held in position by an assistant, a light flannel bandage is applied from the toes to just below the wound. A similar bandage is applied to the thigh, from above the wound to as high as the groin. This is done for the double purpose of giving support to the circulation, and also of protecting the limb from the effects of the hot paraffine. The posterior splint is now applied with a gauze bandage soaked in the hot paraffine. This gives considerable firmness, but, before the paraffine consolidates, the position of the bones should be ascertained, and, if they are in the least degree out of position, the disarrangement must be remedied. The anterior splint should now be applied, and retained in position by gauze bandages, soaked in the same way as before. When these are sufficiently consolidated, the edges of the wound are brought together by interrupted wire-sutures with intermediate sutures of carbolized catgut. A large-sized drainage tube is introduced at each angle of the wound, passing in sufficiently far to insure free discharge. If, as is sometimes the case, oozing goes on, a large soft sponge may be placed over the wound, and retained in position by a bandage of antiseptic gauze. Two strips of lint soaked in paraffine, and allowed to cool, are now placed around the edge of the splint, close to the exposed skin, so as to prevent blood or discharge of any kind from passing beneath the splint. The wound is then dressed after the manner of Lister, the eight-ply dressing completely encircling the limb and splint, passing beneath the arch of steel, and extending above and below the wound to about a hand's breadth on either side.

The operation and subsequent application of the splint should be conducted under the spray. In all the last fifteen cases treated, the splint was not removed until the soft parts had united, and in some not before complete and satisfactory bony union had been obtained. In the subsequent dressings, the spray should also be used. In several of the cases here alluded to, union of the soft parts progressed without any suppuration, and in some the amount of pus was inconsiderable. The great object is to maintain perfect and absolute rest; by this I mean absolute fixity of the bones, and but slight disturbance of the soft parts—not more than occurs in passing a sponge over the face of the wound, to remove any discharge that may be there. For the first few days the dressings may require to be changed frequently. It is seldom that they demand removal before the end of 24 hours, but if the oozing of blood and serum be very great, and the dressings become soaked, they should be changed sooner. The apparatus being applied with gauze bandages and paraffine, and a good layer of paraffine covering all, the discharge has no tendency to trickle beneath the splint, thereby soiling the flannel bandage and giving discomfort to the patient. The drainage tubes should at each dressing be removed and cleansed; if this be not done, drainage will not be thoroughly maintained, the tubes very soon becoming blocked up; they may with advantage be clipped off at each dressing, and by gradually shortening them, the process of union will be favored. The wound may be syringed out, if there is anything likely to offend, which does not flow away; but, as a rule, the less the parts are disturbed the better. It is very objectionable to disturb or separate the flap from its bed by injecting forcibly an antiseptic lotion of any kind. This I have seen done, and have always regarded it as hurtful. We must believe that union is progressing; and to disturb a wound with any fluid will do no good, but, on the contrary, will in all likelihood separate and tear the delicate structures, and retard the process of cure. As the discharge in many cases is very inconsiderable, it would be far better to discard the use of the syringe altogether, and simply wipe away any matter that requires to be removed with a sponge or piece of lint. The drainage tubes ought to be removed when the surgeon believes that they have done all that they are expected to do. There is as much error in maintaining the drainage tubes too long *in situ*, as there is in doing without them altogether.

The wire sutures do not require to be removed for a considerable time, as they create very little disturbance. I have been in the habit of leaving them undisturbed until perfect union of the soft parts has been obtained. The catgut sutures seldom, if ever, require to be removed, as the deeper portion is absorbed, and that outside can be readily wiped away. The surgeon must be ever on the alert for the presence of pus. Should any collection form, from pus being retained in the meshes of the cellular tissue, it should be freely opened. Nothing can lead to greater disaster in surgical cases than pent-up pus, and in the after-treatment of excision of the knee-joint the greatest care and watchfulness should be exercised to guard against the occurrence of any such complication.

The apparatus of Dr. Watson appears to answer the requirements better than any other that I have myself used, or have seen in use. It was to me a matter of regret, in the treatment of my earlier cases of excision of the knee-joint, that no suitable splint had been suggested, and in reading over Dr. Watson's book on this subject, and viewing his illustrations, I must admit that I still doubted the practical utility of the apparatus suggested. It was chiefly with the hope of gaining increased steadiness between the ends of the bones that, in 1868, I designed and carried out section of the bones in the way above described.[1] I had experienced the benefit of this method with the use of an iron splint, a modification of that used by Sir W. Fergusson, and the results were satisfactory in giving greater steadiness between the bones, and a subsequently straight and well-shaped leg. Having obtained such favorable results, I naturally felt some reluctance in adopting any novelty, however strongly recommended.

Dr. Watson's apparatus was first used by me in 1878, and all the cases operated on in the Montreal General Hospital since that date have been put up in the same manner, with some slight change, according to circumstances, such as substituting paraffine for the plaster of Paris. The advantages to be claimed for this form of splint are: greater steadiness between the bones and greater comfort to the patient, permitting free motion of the body without disturbance or alteration in position of the bones at the point of section. The confinement becomes less irksome, and there is less risk of the occurrence of bedsores. It is evident that bedsores are liable to form in patients held down in one position for weeks together; any change in the position of the body—any movement, however slight—is always grateful to a patient after an operation. Dr. Watson has pointed out that the various splints in use will permanently fix the leg and foot, but that the thigh-bone has a constant tendency to rotate outwards; the buttocks will sink into the bed, and the patient will, through sheer discomfort, rest on the outer side of the thigh, thereby seriously altering the axis of the bone. Before using this apparatus, the want of steadiness between the bones was a constant source of anxiety, and to prevent bedsores, I had been in the habit of having the patient raised from his bed, and, while held up, having his back carefully bathed and cleansed, and thoroughly dried, and having him replaced on a freshly-prepared bed. This was an ordeal greatly dreaded by the patient, although performed with great care, and with the help of many assistants. With Watson's apparatus, however, aided by suspension of the limb, there is such firmness, with freedom of motion, that I have seen patients, before the end of the first week, able to sit up with comparative comfort; and in attending to the calls of nature they have been able to swing themselves out of bed, and get on to a close-stool or chair placed at the bedside. The advantage to the *morale* of the patient will also be apparent.

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[1] Canada Medical Journal, vol. vii., page 318, 1871.

In putting up the limb after excision, the surgeon may employ plaster of Paris, or paraffine, or a combination of both plaster and paraffine—this is a mere matter of choice. The plaster makes a firmer splint—it is heavier—but from absorbing the discharges it soon becomes foul; moreover, when the spray is used in dressing the wound, should it be necessary to repeat the dressing frequently, the plaster will soften down and be less efficient. To obviate all these disadvantages the plaster may at the outset be coated over with paraffine, or else paraffine may be employed without plaster; it is quite strong enough, and forms a lighter splint; it is always sweet and clean; any discharge of blood or serum, or of pus, will trickle away, and will be taken up by whatever dressing is applied to the wound. The front splint, if made of steel and if fitted beforehand to the limb, will bind and keep the parts in very accurate apposition. In its construction it should have one or two hooks; one, as shown in the engraving, Fig. 008, is all that is really necessary, and this is used for the purpose of suspending the limb in a Salter's swinging cradle. This contributes greatly to the comfort of the patient.

With respect to closing the wound, I have been in the habit of leaving this to the last, and I think with advantage. The bones during the application of the splint should be under the charge of the surgeon or of an assistant, whose duty should consist in preventing any displacement of the bones after their adjustment, even to a slight degree. When once the plaster or paraffine has set, there is no chance of displacement: the wound can now be closed, the edges brought accurately together, and perfect drainage secured at both angles. The gauze dressing should then be applied, and in applying it that portion of the splint which supports the popliteal space must necessarily be included. This method has been adopted in all my recent cases, and I have had no reason to regret its employment. It is well not to disturb the wound by too frequent dressings; but, again, to leave it too long without a change, is an error in the opposite direction. I am not so pronounced a Listerite as to believe it necessary to change the dressing as soon as any discharge shows itself on the outside of the eight-ply wrapper. Of course if it should be abundant, sufficient to soil or soak into the draw-sheet, and should be still soaking through and draining away, I should deem it advisable, for the sake of comfort to the patient, to change and cleanse the wound; but if, as in some cases, serum alone had come away, and had dried, and were not giving evidence of being very considerable, nor, by affecting the temperature, of creating any irritation, I should leave the limb at rest. In this particular I am impressed with the advantage of watching scrupulously the temperature chart; any rise in temperature indicates some local irritation, if not threatened suppuration; and if this continues for several days together, it is, in my opinion, a sure indication of the presence of pus. In some of my later cases, very few changes of the dressings were required; in Case No. 27, of the Table, that of a young girl, the dressings were changed five times only; complete union of the soft parts was found to exist, and the antiseptics were discontinued, on the 23d day from the date of operation. The splint, however, was not removed until the thirty-fifth day.

TABLE OF TWENTY-EIGHT CASES OF EXCISION OF THE KNEE-JOINT.

No.	Sex and age.	Condition of joint.	Duration.	Result.	Shortening.	Days in bed.	Operator.
1	M. 18	Chronic disease from injury	7 years	Recovered	1¾ inches	70	Dr. Fenwick.
2	M. 22	Chronic disease from rheumatic inflammation, partial anchylosis	9 years	Recovered	2 inches	56	Dr. Fenwick.
3	M. 23	Partial anchylosis in bent position. Arrest of growth of bones in length	9 years	Recovered	4½ inches	154	Dr. Fenwick.
4	M. 14	Chronic disease...............	10 years	Doubtful[1]	2 inches	....	Dr. Fenwick.
5	M. 16	Complete anchylosis at a right angle	10 years	Recovered	3 inches	125	Dr. Wright.
6	M. 42	Chronic disease...............	....	Amput'd[2]	....	....	Dr. MacCallum.
7	M. 36	Chronic disease from injury	5 years	Amput'd[3]	....	....	Dr. Fenwick.
8	F. 21	Chronic disease...............	5 years	Recovered	1½ inches	84	Dr. Fenwick.
9	M. 22	Chronic disease...............	3 years	Recovered	2½ inches	136	Dr. Drake.
10	M. 19	Chronic disease...............	4 years	Recovered	2 inches	56	Dr. Fenwick.
11	F. 12	Chronic disease with backward dislocation, partial anchylosis in bent position	7 years	Recovered	3 inches	212	Dr. Fenwick.
12	M. 38	Chronic disease from injury	5 years	Recovered	2 inches	98	Dr. Fenwick.
13	M. 17	Chronic disease...............	2 years	Died[4]	....	30	Dr. Fenwick.
14	F. 26	Chronic disease from injury	14 years	Recovered	1¼ inches	54	Dr. Fenwick.
15	F. 28	Chronic disease with suppuration following pleuropneumonia	13 years	Recovered	1¼ inches	60	Dr. Fenwick.
16	M. 15	Chronic disease, anchylosis at right angle	3 years	Recovered	2 inches	34	Dr. Roddick.
17	M. 18	Chronic disease following rheumatic arthritis	8 years	Recovered	1⅛ inches	52	Dr. Fenwick.
18	M. 22	Chronic disease...............	8 years	Recovered	....	131	Dr. Roddick.
19	M. 12	Chronic disease from injury	2 years	Recovered	1⅛ inches	36	Dr. Fenwick.
20	F. 24	Chronic disease...............	4 years	Recovered	1⅛ inches	28	Dr. Fenwick.
21	M. 27	Chronic disease from injury	14 years	Recovered[5]	1¼ inches	....	Dr. Fenwick.
22	F. 11	Chronic disease from injury	4 years	Recovered	½ inches	41	Dr. Fenwick.
23	M. 12	Chronic disease...............	6 years	Recovered	1½ inches	73	Dr. Roddick.
24	F. 11	Chronic disease, anchylosis at right angle	3 years	Recovered	1½ inches	72	Dr. Roddick.
25	M. 16	Chronic disease from injury	11 years	Recovered	1½ inches	65	Dr. Fenwick.
26	F. 5	Chronic disease from injury	2 years	Recovered	1 inch	62	Dr. Roddick.
27	F. 21	Disease from cold, and subsequent fall	6 years	Recovered	¾ inch	39	Dr. Fenwick.
28	F. 23	Chronic disease from injury	3 years	Recovered	½ inch	36	Dr. Fenwick.

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[1] Patient taken to the country by his friends; results not hopeful.

[2] No union of bones; the patient insisted on having the leg amputated.

[3] Partial union of bones. Contracted smallpox. Extensive suppuration, necessitating amputation.

[4] Died from pyæmia.

[5] Splint removed thirty-ninth day, firm union; allowed to get up; goes out on gallery.

TUMORS.

BY

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Introduction.

Although tumors are with justice regarded as a species of the great class of hypertrophies or overgrowths, the difference between the species and the class are so great, when typical examples are compared, that the relationship between them well-nigh disappears. A tumor is a hypertrophy, but it is something more and something less than a hypertrophy. It is an overgrowth of tissues, but not limited in its extent or capabilities. It tends to continuous and extravagant increase of bulk, appropriating to its own use material which ought to be applied to the nourishment of the natural structures of the body. It is not adapted, nor does it affect to adapt the natural structures, to perform increased amount of work. It has no inclination to preserve the normal shapes of parts, but, on the contrary, a distinct intention to disfigure and deform, or even to deface them past all recognition. It is derived from the tissues of the part in which it first grows, yet does not of necessity reproduce them, or, if it does so, often reproduces them in a disorderly fashion; or, reproducing them in a perfect form and orderly, separates them by the peculiarity of its growth from the parts in the midst of which they lie, and to which they might apparently be useful. Certain of the great groups of tumors present characters more remarkable than these; for they may be disseminated in tissues and organs remote from that in which the primary tumor grew, and not resembling it in structure or in function. The property common to hypertrophies and tumors is impulse to production. But in the hypertrophy the impulse is limited, purposive, orderly, even desirable; in the tumor it is practically without limit, useless, ill-regulated, disastrous. Yet, great as are the differences between the extreme instances of hypertrophy and tumor, specimens may be found of which it is difficult or impossible to decide to which category they shall be considered to belong. Of these, the growths which have been called by Paget[1] "continuous outgrowths," are examples. Uninterruptedly continuous with some one of the natural tissues, and formed of similar elements, it is uncertain whether they spring from a limited area of the part in which they grow, or are due to a general overgrowth of all its elements. Enlarging the tissue they affect, they yet tend rather to distort than to preserve its natural shape. Sometimes attaining an enormous bulk, they are, nevertheless, for the most part limited in growth. They are thus hypertrophies which may develop some of the distinctive properties of tumors proper; or they are tumors proper whose powers are limited by the conditions which influence hypertrophies.

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[1] Lectures on Surgical Pathology, vol. ii. p. 22. London, 1853.

Etiology of Tumors.

While hypertrophies, unless they be congenital, are by general consent admitted to be due in the large majority of instances to increased use of the part which is hypertrophied, this cannot be maintained of tumors, which are attributed to many causes; indeed, to almost every cause save this. Thus, age, sex, injuries, inheritance, inflammation, anxiety, irritation, hyperæmia, the inclusion of embryonic tissues, parasitism, are all and severally claimed as causes of the origin of tumors. Of some of these, there can be no question that they predispose to tumors, and especially to certain varieties of tumor. Youth, for example, is a protection from almost every form of carcinoma. *Age*, on the other hand, with the accompanying decay or altered life of tissue, renders almost every epithelial structure, but some much more than others, liable to carcinoma. *Sex*, less perhaps than its associated conditions, increases the liability to tumors of certain tissues or organs—the breast, in woman, to tumors of every kind; the tongue and the œsophagus, in man, to carcinoma. *Anxiety* is thought by many surgeons to predispose especially to carcinoma. The effect of *chronic inflammation* and *long-continued irritation* in producing tumors may be illustrated by numerous examples. The gradual transition of so-called psoriasis and ichthyosis of the tongue to epithelioma, of chimney-sweeps' warts to cancer, of simple sores and warty conditions of the lips to epithelioma, are familiar to every surgeon. Of late years the predisposing power of inflammation has been rated much more highly, for it has been shown that long-continued inflammation of the nipple and areola tends undoubtedly to carcinoma of the breast; and it is thought that carcinoma is more liable to attack breasts which have been the seat of previous inflammation than those which have never been inflamed.[1] The evidence in favor of this doctrine is not as yet conclusive. Dr. Formad[2] carries the view of the inflammatory origin of tumors so far as to express the opinion that nearly all tumors are direct effects of inflammation. He supports this statement by showing that some tumors are directly traceable to inflammation, and that certain results of inflammation resemble in their structure certain tumors. But a perusal of his paper leaves the impression that he confuses the causes of inflammation with the inflammation which is caused, and that he forgets that mere resemblances of structure are not absolute evidence of identity of origin.

Tumors are, with good reason in some instances, thought to be *inherited*, for the children of persons who are the subjects of tumor sometimes not only suffer from tumor, but even from the same variety of tumor, in precisely the same organ or tissue. Thus, osseous tumors, symmetrically placed on certain of the long bones, may occur on the same bones in father and child. A mother and her daughter may both suffer from carcinoma of the breast. But the laws of the inheritance of tumors, if such laws be admitted to exist, are singularly limited in their extent, and appear almost eccentric in their incidence. Only a few varieties of tumor appear capable of being inherited, or at least of being frequently inherited; chiefly the osseous amongst the innocent tumors, and both sarcoma and carcinoma among the malignant growths. The inheritance of osseous tumors is generally very regular when it occurs, for the tumors are of the same kind in parent and offspring, and affect corresponding bones and parts of bones. But the inheritance of malignant tumors is far less regular, although apparently far more frequent. The tumors are not necessarily of the same variety in parent and offspring; the mother may suffer from carcinoma, the daughter from sarcoma; or the father may suffer from spindle-celled sarcoma, the son from glioma. The tumors are not necessarily of the same organ or tissue in both generations; the mother may die of tumor of the breast, the daughter of tumor of the uterus; or the father of tumor of the tongue, the son of tumor of the femur. Nor can inheritance, even when it is thought to exist, always be traced directly to the parents, but has to be sought in grandparents, in uncles or in aunts, or even in persons more distantly related. The age at which a tumor, supposed to be inherited, occurs, is often not the same in the transmitter and in the inheritor. Even this modified form of inheritance of malignant tumor is only discovered once in every five or six cases among hospital patients, and about once in every three or four cases among private patients, whose family histories are more perfect—a proportion so small that it is scarcely to be wondered at that doubts have been cast upon the whole theory of inheritance. Mr. Cripps has pointed out[1] that, if parents and children are alone considered, the death-rate from cancer in the parents of cancerous patients is scarcely greater than the proportionate death-rate from cancer to the general death-rate of adults in the community, and that therefore, quite apart from inheritance, one cancerous patient in so many cases must have had a cancerous parent or relation. Probably the kind of evidence which has lent most support to the theory of inheritance, is that derived from the histories of certain families. Sir James Paget[2] speaks of a lady who died "with cancer of the stomach, one of her daughters died with cancer of the stomach, another died with cancer of the breast; and of her grandchildren, two died of cancer of the breast, two of cancer of the uterus, one of cancer of the axillary gland, one of cancer of the rectum." Broca[3] mentions a case even more extraordinary than this, in which, of the members of a particular family who lived to reach adult life, very few escaped death from cancer. Cases such as these, although they are by no means numerous—nay, are very rare—must inevitably attract attention and secure adherents to the party which believes strongly in inheritance. It must be admitted, however, by the stoutest partisans of the theory, that it is exceedingly difficult to explain *what* is transmitted or *what* is inherited. It is not the tumor itself which is inherited, for congenital tumors are comparatively seldom claimed to be inherited. It is not the tendency to a particular form of tumor, or to tumor of a certain organ or tissue, which is inherited. What is it, then, which is inherited? Is it a germ, or collection of germs, or a tumor-parasite, or merely a weak condition of certain organs and tissues, which renders them liable, under the influence of some exciting cause, to produce such tumors as sarcomas and carcinomas? Surely the evidence in favor of the inheritance of malignant growth is yet by no means satisfactory.

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[1] Billroth, Deutsche Chirurgie, Lf. 41; Fischer, Deut. Zeitschrift f. Chirurgie, 1881; Oldekop, Langenbeck's Archiv, 1879.

[2] Transactions of the Pathological Society of Philadelphia, vol. x. pp. 248–294. Philadelphia, 1882.

Within the last few years,[4] Cohnheim has put forward a new theory to explain the occurrence of new growths, but particularly of heterologous growths. It is, that in an early period of the development of the embryo, more cells are produced than are necessary for the foundation of the various parts of the body, and that there remain behind, therefore, unused masses of cells, probably only of small dimensions, but possessing great capabilities on account of the embryonic character of the cells. Under the influence of an excitement, an increased flow of blood, for example, these masses may develop into tumors. This theory scarcely admits of demonstration: its chief claim to credence rests, indeed, on the insufficiency of other theories to explain the occurrence of every variety of tumor under every possible condition. But the difficulties in accepting it are so great that they appear almost insuperable. It is scarcely conceivable that masses of embryonic tissue can remain locked up in developing or fully developed tissues, that they can remain unchanged and inert in the midst of continual change and action during a period, in some instances, of half a century, and then be capable of springing suddenly into life and action on the application of so slight a stimulus as an increased flow of blood in their immediate neighborhood.

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[1] St. Bartholomew's Hospital Reports, vol. xiv. p. 287. 1878.

[2] Pathological Society's Transactions, vol. xxv. p. 319. 1874.

[3] Traité des Tumeurs, t. i. p. 151. 1866.

[4] Vorlesungen ueber allgemeine Pathologie. Berlin, 1877, Bd. i. S. 622.

The theory of *parasitic origin*, when applied to malignant tumors, offers at the present moment greater attraction than any other. It affords an opportunity of explaining many circumstances in the life-history of sarcoma and carcinoma, almost inexplicable on any other theory, especially the invasion of lymphatic glands and general dissemination. It cannot, I think, be maintained that the tumor is the parasite, for its elements are undoubtedly derived from the natural textures of the body. But it may, and probably will be proved, that the tumor contains the parasite, such a parasite for example as the bacillus of leprosy or of tubercle. The close resemblance of the processes of the malignant tumors to those of certain of the infection-tumors, especially tubercle; the manner in which malignant tumors are developed in distant portions of the body; the rapidity with which the transit is in many instances effected; the resemblance of the secondary masses to the parent growth; the obstinate hold which malignant growths maintain, all favor this view. That there are objections to the theory of parasitism, I am well aware, but some of the most important of them may be met. Thus, to the objection that no parasite has been discovered in any tumor, the answer is obvious: the parasites of leprosy and tubercle have only recently been discovered. The objection that tumors are not inoculable, or infectious, or contagious, may be answered by pointing out that tubercle does not appear to be readily infectious or contagious, and that the difficulty of carrying out inoculation experiments successfully is much greater for tumors than for tubercle; for it is evident, from what we know of their life-history, that they require certain very favorable conditions for their first production. When the nature and the situation of the parasite has been discovered, it may then be found possible to conduct inoculation experiments with success. Among the circumstances which tend particularly to encourage the belief that malignant tumors are due to the presence of parasites, the following may be mentioned. Actinomycosis, which stands on the border-line between tumors and infection-tumors, has been already discovered to contain, and probably is due to, a parasite or fungus. The lympho-sarcoma of the lungs of the cobalt miners of Schneeberg,[1] undoubtedly a true tumor-disease, occurs only amongst the miners in the cobalt-pits, killing all the men who work there for a certain number of years, but affecting none of the persons in the neighborhood who are not employed in the pits. The green color and rapid dissemination of green cancer (chlorosis), with the invariable presence in the tumors of very numerous, minute, highly refractile molecules, may also be mentioned. Even the geographical distribution of cancer, as pointed out by Dr. Havilland,[2] may tend towards the same conclusion. For he has found from statistical research, that, while the high and dry lands are very free from cancer, the courses of large rivers subject to seasonal overflow, are hotbeds of cancer; which may suggest that the organisms of cancer thrive only or chiefly in moist districts, or in the tissues of those who reside in moist, river districts.

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[1] Hesse, Archiv d. Heilkunde, Bd. xix. S. 160.

[2] Journal of the Society of Arts, vol. xxvii. No. 1367.

Whether various kinds of malignant tumor are due to different forms of micro-organism, or to modifications of a single organism, can scarcely be discussed. Nor can the questions of the entrance, maintenance, growth, and influence of the parasite be dwelt upon. But I feel confident that the rapid advance in the knowledge of micro-organisms will lead, ere long, to the discovery of tumor parasites.

Some of the conditions which have been mentioned as predisposing, are also exciting causes of tumors—inflammation and long-continued irritation, for example. The hyperæmia, which Cohnheim regards as an important exciting cause, is present in most of these conditions.

Course and Growth of Tumors.

A tumor, once formed, tends always to maintain its size, or to increase in bulk, and this maintenance or increase of size is generally quite independent of the conditions of the whole body. The latter may remain unchanged or even waste, but the tumor grows. It rarely becomes smaller, and almost never disappears, either spontaneously or under treatment. It may, however, though rarely, die, and it may wholly, or in part, slough out.

The increase may be by interstitial growth, by additions to the surface, or by infiltration. An illustration of the first method may be observed in any growing fatty tumor. The small portion of protoplasm between the fat-cells gradually enlarges; a tiny drop of liquid fat appears within it; the drop grows larger, and, in time, flattening out the protoplasm around it, forms a new fat-cell. Of surface-increase, an admirable example may be found in the growth of a cancellous exostosis. The bone is covered with a layer of hyaline cartilage, which, becoming ossified in its deepest layers where it is continuous with the cancellous bone, maintains its thickness and provides for the increase of the tumor by the addition of new cartilage to its surface. Growth by infiltration may be studied in carcinoma, the elements of which are, as it were, thrust in between the natural textures of the part invaded. Long rows of carcinoma-cells may thus be found lying between and separating the fibres of inorganic muscle, or groups of similar cells are seen between fat-cells or bundles of connective-tissue. The changes in the tissues which are produced by infiltration will be presently discussed.

Of the precise *mode of origin* of most tumors we have no definite knowledge. Many of them may, and probably do, commence, as Virchow has suggested,[1] in the form of granulation-tissue. But this is certainly not the case with all. The origin of carcinoma may often be traced to changes in epithelium, and, without any intervening granulation stage, the carcinoma cells are derived from the normal epithelial cells. All primary tumors indeed appear to be derived from the elements of the natural tissues, but the first steps in their development can very rarely be observed. The tissue from which they take their origin, and the tissues in the midst of which they grow, exercise a marked influence upon their structure. The influence of the former is the more powerful, and, so great is the tendency of tumors to assume a structure similar to that of the parent tissue, that the latter may often be inferred by observation of the former. Even if the same structure be not present in the tumor and the parent tissue, the tumor invariably belongs to the same histological series. Thus, a fibrous tissue may produce a fibrous tumor, or a tumor formed of bone or cartilage, or a tumor whose development into fibrous tissue has not taken place (sarcoma).

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[1] Krankhaften Geschwülste. Band i. Vorlesung 5.

If a tumor possesses a structure similar to that of the parent tissue, it is termed *homologous.* But if its structure differs from the structure of the parent tissue, even if it belong to the same histological series, it is termed *heterologous.* Thus, a fibrous tumor growing from the fibrous fascia of a limb, is a homologous tumor; an osseous tumor growing from the same fascia is heterologous. There is, however, a heterology of another kind—that in which a tumor extends into a tissue which belongs to an entirely different series. A tumor of epithelial origin and composed of epithelial tissues, may thus extend into connective tissues; or, *vice versa*, a tumor of the connective-tissue series may extend into tissues composed of epithelium. With heterology, especially with the second form of heterology, is often associated malignancy—but heterology does not necessarily imply malignancy; on the other hand, it may be truly said that a tumor which is, and which remains homologous, is never a malignant tumor.

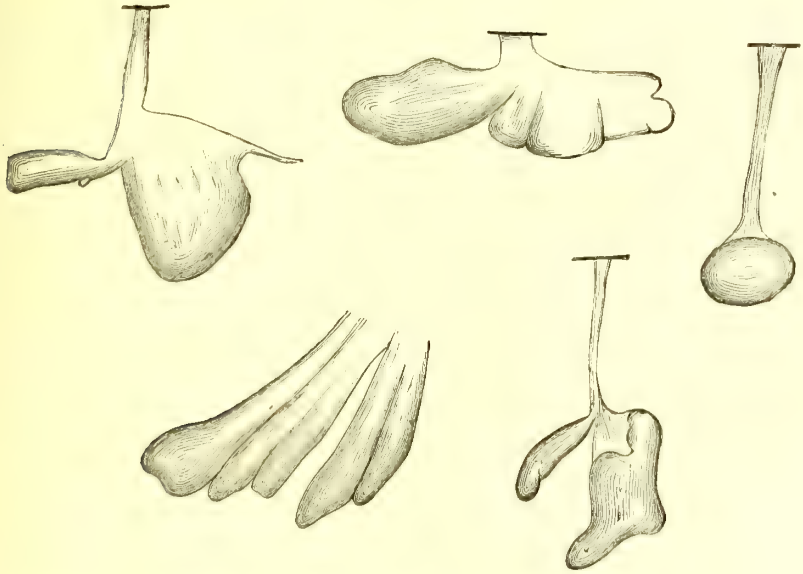
The influence of the parent tissue is not limited to the structure which it impresses on a tumor. As will presently be seen in the life-history of malignant tumors, the origin of a tumor exerts a powerful influence on the course it will pursue, and even on the fact and method of dissemination.

The effects which tumors exercise on the structures in the midst of which they grow, depend largely on the nature of the tumor and the manner of its growth. A tumor which increases slowly by interstitial growth, usually condenses the tissues in its immediate vicinity into a covering or capsule, which, separating it from the surrounding tissues, serves at the same time to connect it with them. Through the capsule it derives support by vessels directly connected with the vessels of the normal parts. Such a tumor produces most of its effects by pressure, causing atrophy and absorption, cutting off blood and nerve supply to near and distant parts. Or inflammation may be lighted up, with resulting adhesion or destruction of the inflamed structures. The infiltrating tumors also produce atrophy and absorption of the natural structures by pressure of their invading elements, but their effects are not confined to these. The invasion is usually preceded or surrounded by a cloud of small round cells, probably colorless blood-corpuscles drawn from the vessels by irritation; these probably are not transformed into the cell-elements of the tumor, but disappear or retract before the advancing growth. The corpuscles of connective tissue, the endothelial cells of lymphatics and bloodvessels, proliferate, and the young cells which result from the proliferation are probably transformed into the cell-elements of such tumors as sarcomas. But, whether a similar transformation takes place in carcinoma, is still a debated point. The alternative is that the elements of the invaded tissues are gradually destroyed and replaced by those of the growing tumor, which increase either by division or endogenous formation. The intercellular structures are at first incorporated in the substance of the tumor, and then, in many instances, destroyed. In the carcinomas, however, though fibrous tissues form the fibrous stroma of the tumor, or at least a goodly portion of the stroma, there is reason to believe that part of the stroma may be formed anew. Certain tissues resist the progress of a tumor far more obstinately than others. The hardness of the tissue is not the only force by which this resistance is effected. Thus, bone gives way more readily than cartilage or tough fibrous membrane; as may be seen in the sarcomas of bones bordering on joints, where the cartilage protects the joint long after every particle of the epiphyseal bone has been destroyed, and in the penetration of the entire thickness of the skull by a tumor which has not yet perforated the pericranium. The explanation of these facts is to be sought, not merely in the toughness of the membrane and elasticity of the cartilage, but, possibly, in the less liability of their cellular elements to be transformed into cell-elements of the tumor.

The *shapes* assumed by tumors are very various, and depend partly on the unequal pressure to which they are subjected as they grow. They may be spherical or spheroidal, oblong, oval, granular, nodular, tuberous, bossed, or lobed. They may be furnished with processes or with outlying lobes or lobules, slenderly connected with the main mass. They may be plexiform or polypoid. It is easily intelligible that pressure must exercise a considerable influence in determining the shape assumed by a tumor growing in the midst of solid parts. If the impulse to growth be equal in all parts of the tumor, those parts which are subjected to the least amount of pressure will naturally attain a larger size than those parts about which the pressure is much greater. But pressure is not the only cause of irregularity of growth. Tumors which increase by infiltration, do not, as has been already stated, infiltrate all tissues with equal facility; and, although toughness and hardness certainly tend to increase the resistance which tissues offer to the progress of an infiltrating tumor, mere toughness or hardness will not account for the resistance, almost amounting to immunity from infiltration, which some tissues exhibit. It is probable that the vascularity, the number and character of the cell-elements, and, perhaps, the liability of the elements to infection, influence the resistance which these tissues offer to infiltration, and consequently affect the shape of infiltrating tumors.

But there are certain reasons which render it almost certain that pressure and infiltration are not the sole, or indeed the chief, causes of the peculiar shapes assumed by many tumors. A large number of tumors are not subjected to pressure which can possibly be regarded as unequal, nor do they grow by infiltration, yet they present eccentric shapes. Thus, tumors which grow in the interior of cavities, intracystic growths, for example, which are surrounded on every side, except at the base, by fluid; and especially tumors

Fig. 760.



Mucous polypi of nose; natural size. To show the shape of polypi.

conveyed, are not always demonstrable between the first growth and the nodules, or between the individual nodules, so that we are reduced to the necessity of believing that the disease extends from the primary growth in long lines in the connective tissue, without special reference to vessels or tissues, and that here and there it buds forth in the form of larger or smaller nodules.[1]

The secondary tumors very frequently affect the neighboring lymphatic glands, commencing usually in a single gland, and spreading from gland to gland until a whole group or chain of glands is converted into tumors. The affection of the glands generally follows the appearance of the primary disease by a distinct interval, usually of several months, sometimes only of weeks, occasionally even years, but varying with the seat and nature of the primary disease. The characters of the disease in the glands resemble these of the primary growths, in some instances only distantly, but generally so closely that sections of a cancerous gland and of the cancerous tumor with which it is connected may easily be confounded. Not only are the cells of the same type, but they are arranged in the same fashion, with the same disposition of the intercellular material. It is, of course, natural to assume that the disease travels along the lymphatics from the primary growth to the affected glands, and, indeed, this is generally admitted; but the precise method of conveyance has been and is still a much debated question. In some cases, cords composed of plugged lymphatics occupy the interval between the glands and the primary disease, and examination of the material which plugs the lymphatics shows that it consists of cancer-cells; but cords, which resemble these in their general feel and aspect, are not invariably plugged lymphatics. Gussenbauer has shown,[2] in one case, in which a very careful investigation was made of such a cord between an affected gland and a primary epithelioma of the œsophagus, that the lymphatics were unoccupied throughout their entire course, and that the induration was due to the presence of long lines or cords of cancer-cells in the walls of the bloodvessels and the connective tissue. In the large majority of cases no connecting cords are observed, and even microscopical examination fails to detect any alteration either in the lymphatics or in the neighboring tissues. Of these cases two explanations may be offered: first, that cancer-cells, or germs capable of developing into cancer-cells, are conveyed by the lymph into the glands, and there grow and multiply; second, that an infecting material is conveyed in the lymph, which, brought in contact with the cell-elements of the lymphatic gland, cause these to assume the form, arrangement, and properties of the cancer-cells.[3] The chief objections to the first explanation are that cancer-cells are not found in the lymph in these cases; that the leucocyte-like cells which are observed cannot be proved to be young cancer-cells; and that we know little or nothing of germs or fragments which are capable of developing into cancer-cells—certainly we do not know enough of them to distinguish them microscopically. To these objections another has of late been added, especially by Gussenbauer in a later and very elaborate paper,[4] that in the earliest stages of glandular disease the first truly cancerous changes are observed in the follicular ends and cords of the affected glands, not in the lymph-paths. Gussenbauer argues strongly in favor of the infection theory, and believes that he has discovered the actual material which infects. This had previously been imagined, by those who hold the infection theory, to be a juice, or a *seminium* in the form of minute particles or young cells. But Gussenbauer declares that it is in all cases a minute molecule, highly refractile, easily distinguishable from the molecules which most cells contain. He has observed vast numbers of these molecules in the lymph-paths and in all parts of the affected gland, and further describes precisely the changes which take place in the cells of the gland, through which they pass to become cancer-cells. No class of cells seems capable of withstanding the infection, for lymph-cells, endothelial cells, connective-tissue corpuscles, and even muscular fibres are transformed into cancer-cells. But the endothelium of the bloodvessels is particularly liable to be infected.

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[1] The exquisite drawings of lymphatics which Sappey has lately published, lead me to think it not improbable that these secondary nodules are due to extension of the disease along the lines of lymphatic vessels.

[2] Langenbeck's Archiv, Bd. xiv. S. 501. 1872.

[3] By *cancer-cells*, let it be understood that sarcoma-cells and carcinoma-cells are equally meant.

[4] Zeitschrift für Heilkunde, Bd. ii. S. 17.

Gussenbauer's paper is admirably worked out, and the statements which it contains are made in so confident a tone that his theory is very attractive. His observations, however, have not yet been confirmed, although two years have elapsed since they were published. Until they have been confirmed or contradicted, they must be regarded with caution: first, on account of the difficulty which must always be experienced in recognizing a particular molecule which has not any very characteristic features, and of observing the exact changes which occur in parts whose structure is so close and confused as that of the follicular ends and cords of the lymphatic glands; second, on account of a grave improbability which the author's account contains. He tells us that the existing cells of the infected tissues, no matter how old, and fixed, and stable they may be, are directly transformed into cancer-cells. So marvellous an effect of a seminium is scarcely conceivable, since it is so different from the effects which we are accustomed to observe. A seminium acting on a cell may be expected to cause swelling and proliferation, and it is perfectly conceivable that the cell or cells which result from this proliferation may assume a very different form and properties from those of the parent cell. The difficulty of admitting the direct influence of the seminium, and the somewhat vague account of the manner in which the arrangement of the cells in acini, or tubes, or groups, resembling those of the primary cancer, is effected, constitute some of the chief objections to the acceptance of these statements.

Either with or without glandular affection, secondary tumors may occur in various organs and tissues of the body. In some instances one organ, as the lung or liver, is the seat of very large or numerous secondary tumors, and no other organ or tissue is affected. In other instances, several parts possessing the same structure, for example, several bones or several muscles, contain secondary tumors. Again, in other instances, organs of a different structure and function, the liver, the spleen, and the kidneys, are affected. And sometimes the disease is widely disseminated through the body, attacking many and different tissues and organs. Dissemination may be accomplished through different channels. The most usual, undoubtedly, is the blood, and the organ whose capillaries are first traversed by blood which passes through the primary disease is that in which secondary tumors may be first expected. Thus, the lungs are secondarily affected by tumors of many different parts; the liver by tumors of the spleen, the stomach and the intestines. But this course is not by any means invariably pursued. Organs far distant from the primary disease, and having no decided connection with it either by blood or lymph vessels, may be the seat of secondary tumors, while those organs which are directly exposed to infection are, so to speak, neglected. From this it may be inferred that all organs are not equally inoculable, or do not all afford a suitable soil for the reception or growth of cancer. And further, there is reason to believe that certain forms of cancer, especially of certain organs and tissues, are much more readily inoculable than others, in parts greatly exposed to infection. In some cases, cancerous emboli of considerable size are probably conveyed by the blood, for the primary disease projects into the interior of large veins, such as the iliac or jugular veins, and fragments are easily separated from the mass. But, in the vast majority of instances, there is no perceptible perforation of a vessel wall, and the infecting material is probably precisely similar to that which is carried by the lymph to the lymphatic glands. Fragments of the primary disease may be conveyed by the inspired air, take root in the lungs, and grow. In this manner some of the carcinomas secondary to those of the larynx and œsophagus are accounted for. The frequent or continual contact of a healthy with a cancerous surface may lead to the inoculation of the former. Thus are formed, apparently, some of the secondary tumors of the mucous membrane of the bladder, where the bladder is the seat of an ulcerated, primary carcinoma.

However different the manner of infection in individual instances, the secondary tumors bear almost always a marvellous resemblance to the primary disease, so marvellous indeed that the nature and seat of the primary disease may frequently be recognized by microscopical examination of sections of the secondary tumors. Even the metamorphoses of the primary disease are often repeated in the secondary tumors, and thus the lungs are filled with cartilaginous growths derived from a chondrifying sarcoma of the testis, or with bony growths from an ossifying sarcoma of the femur.

Recurrence of Tumors.

With the multiplicity of tumors, the question of recurrence may fairly be considered. And here it is important to be sure of the sense in which the term *recurrence* is employed. It is most frequently used to denote the reformation or reproduction of a tumor after removal or destruction. And as reproduction takes place usually within a few months of the operation, the cause of recurrence is, in most instances, justly assumed to be a fragment of the tumor left at the operation. The fragment may be microscopical or may be of considerable size. Both innocent and malignant tumors may recur under these circumstances. Thus mucous and fibrous polypi, as every surgeon knows, recur unless their bases are removed; and sarcomas and carcinomas which seem to have been thoroughly removed, frequently recur with singular obstinacy.

But, if a tumor reappears many years after removal, this is equally termed recurrence, although the second tumor cannot possibly be traced to incomplete removal of the first. In such case, both tumors probably own the same or a similar cause, and there is really no direct relation between them.

A third condition, which is sometimes spoken of as recurrence, is the affection of lymphatic glands after removal of a tumor which has not itself recurred, the glands at the time of the operation not having appeared to be abnormal.

To the last condition the term recurrence should never be applied, for it is obvious that the glands must have been already affected at the time of the operation, although the affection was not sufficiently advanced to be detected. The second condition may justly be termed recurrence, but I think it is desirable to limit the term to the re-formation or reproduction of a tumor within a few months of its removal: first, because it is in this sense that the word is most frequently employed; second, because, when used thus, it carries with it the important admission that the disease was not completely removed. The difference is apparent in prognosis: a surgeon assures his patient, after removal of a fatty or bony tumor, that the disease will not recur; but he certainly does not intend to promise that the patient will never again in the course of his life be the subject of a fatty tumor, in the same region of the body as that from which the first tumor was removed. In this article, then, the term will be employed only in this sense, to denote the reproduction or re-formation of a tumor.

It is, of course, impossible to say how long a period must elapse before a person can be deemed safe from the possibility of recurrence; but it may reasonably be considered that, if, twelve months after an operation, there is no visible or tangible sign of return, the operation is to be regarded as successful. It can scarcely be conceived that, during the period of a year, the disease should be present, perhaps in a microscopic form, and lie dormant, and then break forth into active growth, and in the space of a few weeks or months produce a tumor of considerable bulk. In the histories of cases, recurrence is often made to appear much more tardy than it really is, by the absence of accurate information of the date of re-appearance of the tumor; and the period between the first and second operations is sometimes wrongly regarded as a period free from recurrence. Although recurrence is thus admitted to be due to incomplete removal, the operator is not, by any means, necessarily to blame, in all cases, for the recurrence of a tumor. Some tumors are so situated that it is practically impossible completely to remove them; yet an operation is fully justified by the temporary relief which it affords. On this account polypi of the nose are taken away, even when the probability of their recurrence amounts almost to certainty. Other tumors appear to have been completely removed, and yet recur. Thus do many sarcomas which are inclosed in complete capsules. The tumors are removed, together with their capsules, shelling out like fatty or fibrous tumors; but the capsule does not serve to protect the surrounding tissues from contagion; they are already infiltrated with the elements of the tumor. And tumors which are not encapsuled, certain of the sarcomas and carcinomas, are often difficult thoroughly to define, and therefore difficult completely to remove.

Malignancy of Tumors.

The terms malignant and malignancy have been employed so frequently that it is desirable to define their meaning. Malignancy is expressed in one or more of three different ways: infiltration of adjacent structures, affection of neighboring lymphatic glands, affection of other organs and tissues. The first of these is, on the whole, the most important, for it is probably never absent, and is, in many instances, the only indication of malignancy. Thus the cancerous ulcer termed "rodent," neither affects the glands nor any distant organ or tissue, but its malignancy is expressed in the local invasion of skin, adipose tissue, muscle, bone, the eye—in fact, of every tissue with which it comes in contact. Many malignant tumors appear to be strictly circumscribed, and even confined within firm capsules; but microscopical examination of the immediately adjacent tissues discovers elements of the tumor, and examination of sections of the tumor discovers fragments of normal tissues included in the morbid growth, and, as it were, partially digested by it. This property of malignant tumors renders their complete removal far more difficult than that of innocent growths, but it has been already shown that recurrence is not by any means exclusively a character of malignancy. Affection of neighboring lymphatic glands is a decided expression of malignancy, and is exhibited by every variety of malignant tumors under favoring circumstances. Whenever it occurs it is the most reliable of the clinical indications of malignancy, for infiltration of adjacent tissues may be unrecognizable before removal of a tumor, and multiplicity of tumors is not confined to those which are malignant. The mistake is, however, liable to be made of confounding irritative and inflammatory enlargements of the glands for malignant affection. The multiplicity of malignant tumors, when it occurs, is an indication of the most advanced malignancy, and of the hopelessness of surgical treatment. The disease is no longer regional; it has become general. Infiltration of adjacent tissues and glandular affection are never produced by innocent tumors, if the fashion of growth of certain hypertrophic conditions which are scarcely tumors be excepted; for occasionally a fatty or fibrous outgrowth separates, by a kind of infiltration, such structures as muscular fibres. One such growth I have seen, which formed a tumor of considerable size in the calf of the leg of a young girl, and which contained fibres of inorganic muscles widely separated by the fat.

General Characters and Diagnosis of Tumors.

Most of the clinical features and symptoms of tumors will be considered in the sections which treat of the different varieties of tumor, but certain characters which serve to distinguish all tumors from other diseases which resemble, or are closely allied to them, may be considered here. Thus tumors are generally distinguished from inflammatory swellings by their continual tendency to enlarge, their more clearly defined outline, their mobility, the absence of the most prominent signs of inflammation, the disinclination which they exhibit to suppurate or even to inflame acutely, and the nature and situation of the part affected. The points of difference are, for the most part, more obvious when innocent tumors are compared with inflammations, for they are generally much more movable, more clearly defined, and less inclined to inflame and suppurate, than are malignant growths. The nature and situation of the part affected appear at first sight to be of little moment in the diagnosis. Nor are they of importance in every case; but, in many instances, a consideration of them helps to make the diagnosis much more easy. Thus, inflammations, especially chronic inflammations, of one parotid gland are very uncommon, while tumors are by no means rare; tumors of the epididymis are exceedingly rare, while inflammations are very frequent. Although in a vast number of cases the distinctive characters of tumor are so clear that the question of inflammation cannot arise, there are some cases, especially of carcinoma and sarcoma, where the signs of inflammation are present, and where the characters of tumor are so ill-marked that an accurate diagnosis is impossible. The nature of the case becomes evident only by close observation of its course.

Tumors are usually distinguished from hypertrophies by the fact that hypertrophy commonly affects the whole of an organ or portion of the body, or an entire *reach* of tissue. For instance, the whole of a finger may be hypertrophied, but only one or two of the phalanges are usually the seat of tumors. Hypertrophied parts generally retain many of their normal characters; all the tissues are enlarged in an almost equal degree, and thus the form and general proportions of the part are relatively maintained. Certain parts of the body which are not infrequently the seat of tumors, such as the parotid and the testis, are scarcely subject to pure hypertrophy. And in parts of the body which are subject both to hypertrophy and to tumors, such as the breast, the tumors are generally more clearly defined and separable from the organ in or near which they lie.

The signs by which tumors proper are distinguished from the infection-tumors, are sometimes very minute. Tuberculous and syphilitic affections are frequently mistaken for tumors; nor is this remarkable when it is borne in mind how closely the course of tubercle resembles that of some malignant tumors, and how prone syphilis is, as Hutchinson has pointed out, to produce imitations of other diseases. The source of the infection-tumors, which would be an important aid to diagnosis, is not in every case apparent, but they are almost invariably associated, soon or late, with inflammation, and, if they do not actually suppurate, are a frequent cause of suppuration in the adjacent structures. Associated signs of syphilis and tubercle are in many instances present and easily discoverable.

In the diagnosis of an individual case of tumor, many other points besides the local features must be taken into account. The *age* of the patient is often of extreme importance. Numerous examples in proof of this may be adduced: almost the only true tumor which attacks the testes of boys under ten years of age, is sarcoma; inflammations of the breast are common during the child-bearing period, carcinomas are common after the inflammatory period has passed: carcinoma of any part of the body is almost unknown in persons under adult age; cartilaginous and bony tumors commonly affect children or young adults. *Sex* often plays an important part in diagnosis. For, setting aside those parts of the body which are peculiar to the sexes, and those which are more highly developed in one sex than the other, certain regions, apparently of equal importance in both sexes, are much more liable to tumors in one sex than in the other. Thus, the tongue and the œsophagus are much more often the seat of carcinoma in men than in women. The lip and the external ear are rarely cancerous in women, frequently in men. The *affection of neighboring lymphatic glands* has already been alluded to as an effect of malignant tumors which is not produced by innocent growths. It is a frequent association of acute, not so frequent of chronic inflammations. It is of common occurrence in connection with tubercular affections, but is scarcely ever observed as the result of gummata.

It is not merely one or the other of these conditions which is of value in diagnosis. It is the *combination of conditions* which establishes certainty. A firm, rapidly-increasing, ill-defined tumor in the breast of a woman more than forty years of age, with retraction of the nipple, adherence of the skin, enlargement of one or more axillary glands, and a history of six or nine months' duration, is practically certain to be a carcinoma. A foul sore, with indurated base and edges, of the lower lip of a man of seventy years, which has been forming slowly during twelve or eighteen months, and is associated with enlargement of the glands beneath the jaw, is surely a squamous-celled carcinoma (epithelioma). But, should the tumor lie in the breast of a suckling woman of twenty-five years old, and be of two or three months' instead of six or nine months' duration, the diagnosis is completely changed. The probability is now as strongly in favor of chronic inflammation as it was formerly in favor of carcinoma. Or, should a woman of twenty years bear the foul ulcer on the lower lip, the diagnosis will be syphilis, not carcinoma.

In the diagnosis between innocent and malignant tumors, the *duration of disease* and *rapidity of growth* are often, apart from other signs, of value. Thus, the diagnosis of the malignant character of tumors of the upper jaw, depends mainly on the relatively large size to which they attain in the space of a few weeks or months. In the same respect, the *part of the body affected* is often of importance. Thus, the eye is very rarely the seat of innocent tumors, not uncommonly of malignant tumors; the testis is much more often attacked by sarcoma and carcinoma than by any innocent growth; the gums are often the seat of innocent tumors (fibrous epulis), rarely of malignant growths.

The nature of a doubtful swelling may often be proved by *puncture* with a grooved needle or a fine trocar and canula. This method of diagnosis is especially valuable in the case of tumors situated deep in the substance of an organ like the mamma, where it is sometimes impossible to be certain whether solid or fluid is present. It is employed, too, when the question lies between an abscess and a softening carcinoma, or a sarcoma which has become red and semi-fluctuating. The "emporte-pièce histologique" is not as valuable an aid to diagnosis as it was at one time hoped it might be; only a very tiny fragment can be withdrawn, not generally large enough to cut a section from; and even this fragment may be withdrawn from a portion of the tumor the structure of which is not characteristic. Moreover, the introduction of the emporte-pièce is painful, and is not easily borne by patients, especially ladies, without the aid of anæsthesia.

The diagnosis of malignant ulcers may often be made with unerring certainty by scraping the surface of the ulcer gently with a knife, and submitting the scraping to the microscope. This method can only be employed with advantage in the case of ulcerated, squamous-celled carcinomas (epitheliomas), the surfaces of which yield epithelial cells, and not unfrequently cell-nests. The cells are distinguished from the normal epithelium by the absence of typical characters. They vary much in size and shape; some larger than the normal cells, some smaller, some round, some oval, some angular, and others tailed. The nuclei are large, as compared with the size of the cells, and many of the cells contain two or several nuclei, or even several smaller nucleated cells. Almost all the cells are very granular. Mingled with these altered epithelial cells are blood and pus corpuscles, débris of decaying tissues, and, in some situations, schistomycetes. But the epithelium forms the characteristic and preponderating element. When it is uncertain whether an ulcer is epithelial, or tuberculous, or syphilitic, the diagnosis of epithelioma may by this means be usually made without difficulty, for scrapings of tuberculous and syphilitic ulcers yield only pus and blood, with débris, and occasionally schistomycetes.

Treatment of Tumors in General.

The treatment of tumors can only be considered with reference to palliation and operation, for few, if any of them, can be cured by medicine. Indeed, the only tumors which appear to yield to the internal administration of drugs, are some of the fatty outgrowths and certain glandular enlargements, of which it is by no means certain that they are really tumors.

A tumor may be removed or destroyed for one of the following reasons: pain, inconvenience, disfigurement, damage or danger to important structures, danger or detriment to health, danger to life (immediate or remote). A tumor may be removed for all these reasons, and few tumors are removed for only one among them. Tumors are frequently removed chiefly on account of the pain of which they are the seat: the "painful subcutaneous tumors," for example—small, fatty or fibrous tumors, exquisitely painful and tender. Small cysts and tumors seated in the eyelids are occasionally removed on account of the inconvenience or annoyance which they occasion, even when they scarcely at all disfigure, and are not painful. For the same reason, a working man will desire to be rid of a cartilaginous tumor of the phalanx of his finger; it interferes with the due performance of his work. Disfigurement and the fear of disfigurement often demand the removal of a growth which might otherwise be left untouched. For this reason sebaceous cysts of the scalp, which have attained a moderate size, are removed from the heads of ladies who are otherwise scarcely inconvenienced by them. A rodent ulcer of the face is very freely removed or destroyed, in some instances chiefly with the object of saving an eye which is imperilled by its gradual growth. The detriment to health which is produced by hemorrhages from a fibroid polypus of the uterus, or from a glandular polypus of the rectum, is alone sufficient to necessitate its removal. And the danger to life incurred by the presence of an innocent tumor of the larynx—a papilloma, for example—calls loudly for early and effectual treatment.

A tumor which produces neither of the conditions just described, may yet be radically treated on account of the certainty that ultimately it will produce one or other of them.

For the means by which removal of a tumor may be effected, they are numerous—caustics, cautery, scissors, knife, ligature, écraseur. The choice among these depends partly on the nature and situation of the growth, partly on the inclination of the operator, and partly on the condition of the patient. Superficial growths, such as capillary nævi, may be well treated with caustics or the cautery; subcutaneous nævi, and pedunculated warty and fibrous growths, with the ligature. The tongue may be removed, according to the preference of the operator, with the cautery, or with scissors, knife, or écraseur. Small cysts and cutaneous epitheliomas, in very old or feeble persons, may be more safely removed with caustic than with the knife; and patients whose condition of health forbids the use of the knife, may often be quite safely treated by means of caustics or the cautery. For the very large majority of tumors, however, the knife is employed by almost all surgeons as the readiest, the most easily managed, and the most efficacious means of treatment. No other instrument can be so delicately or so roughly used as occasion seems to require. No instrument can be so rapidly employed to remove large masses of tumor, none to dissect so closely round an innocent growth which adheres to the surrounding structures, none so well to spare the skin and leave so small and narrow an opening. The special means which may be recommended for the treatment of different varieties of tumor, will be further discussed in the sections on the several forms of growth.

Tumors which are neither painful, nor inconvenient, nor disfiguring, nor threatening important structures, nor detrimental to health, nor dangerous to life, nor likely speedily to become so, may be left untreated, and simply watched from time to time, to be sure that they have not changed their characters. They require no palliative treatment, for there are no discomforts which need palliation. Occasionally, however, it is deemed desirable to remove a tumor even thus innocuous, to allay the mental anxiety of which it is the source. On the other hand, a tumor, even when it is the seat of pain, or a source of grave inconvenience, may be deemed unfit for operation on account of the ill-health or age of the patient. And a tumor which is not growing larger may remain untreated, because the disfigurement or damage produced by removal would be greater than that produced by the presence of the tumor. Again, it is often deemed right not to interfere with malignant tumors when their complete removal cannot absolutely be insured, or when the neighboring glands are extensively involved, or when there are symptoms pointing to implication of internal organs. Operations on the subjects of multiple, innocent tumors, may be undertaken for the removal of one or more of the growths, for the same reasons as those which lead to the removal of a single tumor. But it is not usual either for the patient to demand, or for the surgeon to advise, the removal of a large number of multiple tumors.

Classification and Nomenclature of Tumors.

The classification and nomenclature of tumors have been exercising the minds of pathologists for nearly a century, but particularly during the life of the present generation. With the growth of knowledge of the minute anatomy of tumors, the clinical classification, which was generally employed twenty years ago, came to be regarded as eminently unsatisfactory. In truth, it had during many years been gradually forfeiting its claim to be considered a consistent classification. Certain of the classes were based on the coarse, anatomical characters; certain of them even on the microscopical characters of the tumors. It had become, therefore, a mixed classification, partly clinical, partly anatomical. Its insufficiency for scientific purposes was daily becoming more manifest when, in 1863, it received its death-blow by the publication of the first volume of Virchow's great work on tumors.[1] In this volume the great pathologist clearly established the desirability, nay necessity, of classifying all tumors according to their anatomical characters, and without any reference to their clinical attributes. Since that day the anatomical classification has been gradually growing in favor, and is now generally adopted by surgeons, among some of whom, however, there is still a tendency to regard all malignant tumors as cancers, and to ascribe to all cancers equal and fancied attributes. Although, without question, the present classification is much more scientific than the old, it is just as undoubted that it is defective in certain parts. But the defects are not more numerous and certainly not more glaring than those which are inseparable from the clinical method. And as our knowledge of the whole subject, and especially of the individual tumors of certain classes, increases, there is every reason to hope and believe that the anatomical classification may become the most perfect, and at the same time the most useful, for the purposes of the clinical surgeon.

Many of the classes are arranged without difficulty, and do not differ from the classes belonging to the old method—the osseous, fibrous, fatty, and cartilaginous tumors, for example. Their likeness to normal bone, fibrous tissue, fat, or cartilage, is at once apparent, and a microscopical examination is not needed to confirm the diagnosis. Other classes are arranged with just as little difficulty by the aid of microscopical examination, as the glandular tumors, whose prototypes are the acinous or cylindrical glands. The prototypes of other classes are not so easy to discover, for they exist only in one or two situations in the human body. Of such a kind is mucous tissue, found in adult man only in the vitreous humor of the eye. And for two great classes no physiological prototype can be found in normal, perfect structures. That of the sarcoma has to be sought in embryonic tissues: that of the carcinoma does not exist even in these. The difficulty of deciding on the relative and general position of these two large and important classes, has made one of the chief difficulties in perfecting the anatomical classification. Since no certain physiological prototype of either of them actually exists, it has been possible for each pathologist to decide for himself, individually, the grounds on which a distinction should be made between the sarcomas and carcinomas, and the essential characters of each. There are, therefore, several different definitions of both terms, and the words sarcoma and carcinoma do not carry with them a signification which is at once perceptible and intelligible, like that which belongs to the words chondroma, osteoma, or fibroma. Virchow makes the difference lie in difference of anatomical structure, without reference to origin. Indeed, difference of origin is not admitted by Virchow, who holds that both sarcoma and carcinoma are derived from connective-tissue elements. He therefore considers the presence or absence of alveolar structure as the essential condition of distinction. If the distinction laid down by Virchow could be in all instances relied on, or if any other structural difference could be discovered which could be thoroughly depended on, it would be correct to make the difference between sarcoma and carcinoma solely structural, and thus preserve the uniformity of the anatomical classification. But, unfortunately, although Virchow's structural distinction serves in the large majority of instances to distinguish between sarcoma and carcinoma, it fails in certain cases, partly because the anatomical characters of the disease are indistinct—as it were blurred—partly because sarcomas occasionally present the structure which has been assigned to carcinomas. The untrustworthiness of the anatomical distinction, and the discovery by Waldeyer[1] of the epithelial origin of carcinoma, led to the adoption of difference of origin as a basis of distinction between the two classes. Carcinomas are tumors of epithelial origin; sarcomas are tumors of connective-tissue origin. This is the basis of division on which it appears safest to rely. Most of the tumors can easily be distinguished and classed by examination of their structure, but the difference in their origin serves to supplement and correct the diagnosis. And this does not involve a serious strain of the whole system of classification, for the various classes of tumors are arranged first according to the physiological prototype of each, and also in large divisions according as the prototypes belong to the connective tissue or the epithelial series. Sarcoma thus falls naturally within the one, carcinoma within the other division. It is not, I believe, yet possible to trace back the origin of the two classes in question to the layers of the blastoderm, to derive sarcoma from the mesoblast, carcinoma from the epiblast. An attempt to do this would tend to much confusion, perhaps because our knowledge of embryology is not yet sufficiently reliable. Two examples will suffice to illustrate the confusion to which the attempt would lead. Glioma, a round-celled tumor originating in the connective tissue of the nervous centres, is at present classed among the sarcomas, and the position assigned to it seems justified by its structure and its origin in connective tissue; but the connective tissue of the great nerve-centres is derived from the epiblast, and, as a consequence, glioma would be removed from its present position and classed among the carcinomas. Again, spheroidal-celled (soft) carcinoma of the testicle is derived from the epithelium of the testicle, sarcoma from its connective tissue. The difference in their origin and structure is generally sufficiently evident, and the former tumor is classed among the carcinomas, the latter among the sarcomas. But the entire testis is derived from the mesoblast, and in consequence all malignant tumors of the testis, whether they originated in the epithelium or in the connective tissue, would be classed among the sarcomas as mesoblastic tumors. It will be evident from these two illustrations that the time has not yet arrived for employing the embryonic theory in the classification of tumors, and that it is far more safe and useful, for the present at least, to look for the essential difference between sarcoma and carcinoma in their origin, respectively, from what are generally described and regarded as connective tissue and epithelium.

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[1] Krankhaften Geschwülste. Berlin, 1863.

A difficulty in classification is likely to arise, has indeed already arisen, in connection with the tumors which grow from endothelium. It seems scarcely certain whether the endothelia should be regarded as a separate class of tissues, or whether they should be placed as formerly among the epithelia, or as at present among the connective tissues. For the present, it appears more desirable to consider them as connective-tissue structures, on account of their intimate relation with the connective tissues, the distance at which they often lie from any epithelium, and the great differences which exist between them and the various forms of epithelium. Tumors, therefore, which arise from the endothelia may be regarded as tumors of connective-tissue origin. It is probable that many tumors which are now regarded as sarcomas, are in reality endotheliomas, but at present this is only probable.

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[1] Sammlung klinischer Vorträge, No. 33, 1872.

Thus far we have not learned to recognize with certainty the essential structural characters of the endotheliomas, for very few pure examples of them have been described.

As it is necessary to admit that there are certain defects in the anatomical method of classification, so is it also necessary to allow that the nomenclature is not perfect in all respects. The tumors composed of simple tissues are very properly named in accordance with their structure. Tumors composed of fibrous tissue are fibromas; tumors composed of bone are osteomas. But the tumors which have no named prototype, the sarcomas and carcinomas, possess no natural name. Old names have therefore been applied to them; the term carcinoma has been retained for that part of the old class of cancers which is derived from epithelium; the term sarcoma has, at the suggestion of Virchow, been recalled and applied to the embryonic growths which are derived from connective tissue. It might of course be possible to replace these terms by others more suitable; to replace the term carcinoma, for example, by epithelioma, used as most French pathologists are in the habit of using it. But in German and English-speaking countries this change would be fraught with the gravest inconvenience, and would lead during many years to great confusion. For the term epithelioma, in these countries, is already applied to a particular form of carcinoma, and its occurrence in medical literature would, therefore, be associated with continual uncertainty respecting the sense in which it was employed. The use of the present terms is sanctioned by custom, and, probably, the precision which might be attained by the substitution of more correct terms, would be more than counterbalanced by the inconvenience which would be produced. The following nomenclature of solid tumors will, therefore, be here adopted, cysts being separately considered:—

I. Connective-Tissue Tumors.	1. Lipoma,	
	2. Fibroma,	
	3. Chondroma,	
	4. Osteoma,	
	5. Myxoma,	
	6. Lymphoma,	
	7. Myoma,	
	8. Neuroma,	
	9. Angeioma,	
	10. Sarcoma,	Round-celled, Spindle-celled, Giant-celled, Mixed-celled.
	11. Endothelioma.	
II. Epithelial Tumors.	12. Papilloma,	
	13. Adenoma,	
	14. Carcinoma.	Spheroidal-celled, Squamous-celled, Cylindrical-celled.

The above nomenclature differs in certain respects from those generally followed. Thus, a sub-class of "mixed-celled sarcomas" is introduced to make a place for many tumors which would otherwise be left unclassed. Again, the carcinomas are not divided, as usual, into hard, soft, epithelial, etc., but into spheroidal or glandular-celled, squamous-celled, and cylindrical or columnar-celled, according as they are derived from, and present the characters of, one or other of these different varieties of epithelium. All the hard and soft carcinomas fall within the first sub-class, the flat-celled epitheliomas within the second sub-class, and the cylindrical epitheliomas within the third sub-class. No distinction is made between hard and soft carcinomas, because it has become gradually apparent during many years that, whatever minor differences may exist between them, there are no differences which can be deemed essential. Carcinomas which feel hard to the touch, have in many instances the typical structure of soft carcinoma. A hard carcinoma of the breast may be the parent of soft carcinomas in the liver. Glands, secondarily involved from a soft carcinoma, may present the characters of hard carcinoma. The tumors formerly called cylindrical epitheliomas (or, worse still, cylindromas), are not considered as epitheliomas, because they have nothing more in common with the flat-celled epitheliomas, either in structure or in properties, than they have with the spheroidal-celled tumors. They are therefore placed in a separate sub-class, as cylindrical or columnar-celled carcinomas. Colloid, melanotic, and villous cancers are omitted from the general scheme of classification, for reasons which will be mentioned in the section on carcinoma.

The modifications of nomenclature which have just been mentioned, have been introduced into this scheme in order to render the anatomical classification more perfect. There is no reason, because all the classes have not been named in accordance with strict anatomical principles, that the chief sub-classes should not be so named where it is possible. The sub-classes of carcinoma are, therefore, made to harmonize with the sub-classes of sarcoma, and I believe rather with advantage than with detriment to general convenience.

However perfect the general system of classification may be, the classification of individual tumors is always liable to be attended with difficulty. Every tumor is not typical in structure. Every tumor is not composed only of one tissue. The metamorphoses which tumors or parts of tumors undergo obscure their fundamental structure. Nevertheless, most tumors, even if they are not typical in structure, may, with care, be referred to the class to which they properly belong. And tumors which are composed of two or several tissues, may be referred to the class to which the bulk or most of the tissues they contain belong. For certain of these tumors, compound names may need to be adopted. A tumor which consists partly of fibrous, partly of glandular tissue, may be termed an adeno-fibroma, or a fibro-adenoma, as one or the other of these tissues preponderates in bulk or in importance. A tumor composed partly of fat and partly of fibrous tissue, may, in a similar fashion, be termed a fibro-lipoma, or a lipo-fibroma. The mere addition of small portions of a second tissue to a tumor consisting chiefly of one tissue, ought not to be denoted in the name unless some peculiar feature in the second tissue renders it desirable to recognize it.

The main difficulty arises in connection with the classification of tumors whose tissues are markedly or largely metamorphosed. The errors which may be produced by faulty classification and recording of these metamorphosed tumors have already been alluded to, and need no further mention, except to point out the necessity of placing all such tumors in the class to which their basis and essential tissue naturally refer them. But another trouble has arisen from these tumor transformations, namely, a faulty nomenclature, which has led to much confusion in the study of onkology. The osseous transformations, especially, have led to the use of several terms which are neither necessary nor desirable. Of such are osteo-sarcoma, osteoid-sarcoma, osteoid-cancer, osteoid-chondroma. The sense in which these terms were originally used has, for most of them, long since been forgotten. Each of them has been employed in more than one sense, and when either of them, except perhaps the last, is now employed in medical literature, it is quite uncertain, unless it be accompanied by an explanation, which of several meanings is to be attached to it. "Osteo-sarcoma" may mean a sarcoma containing bone, a sarcoma growing from a bone and containing bone, a soft tumor growing within a bone. "Osteoid-sarcoma" and "osteoid-cancer" are applied to malignant tumors occurring in connection with a bone, and to ossifying and calcifying sarcomas. "Osteoid-chondroma" is usually employed to denote the presence of a tissue, neither perfect cartilage nor perfect bone, but resembling bone which has been deprived of its earthy salts. The mere fact that these terms may bear several different significations, shows that they are undesirable. And they are as unnecessary as they are undesirable, for the transformations which some of them express can be far better expressed in simpler terms. A sarcoma which has been transformed in large part into bone, is an ossifying or ossified sarcoma, and had far better be termed ossifying or ossified than osteo- or osteoid-sarcoma. A sarcoma which is largely calcified is more appropriately termed a calcifying sarcoma than an osteoid-cancer or sarcoma. The tumors which are named osteoid-chondromas are almost invariably chondrifying sarcomas. For these and similar terms, then, others far more appropriate and more intelligible may advantageously be substituted, and a great obstacle to an easy comprehension of tumor nomenclature be thus removed.

SPECIAL VARIETIES OF TUMOR.

Lipoma or Fatty Tumor.

A tumor composed of adipose tissue, resembling histologically and chemically normal adipose tissue, may originate in the fatty and areolar tissues of almost every region of the body, but in the large majority of cases grows from the subcutaneous tissues of the extremities. The lower part of the neck, the shoulders, and the arms are especially liable to lipoma. The scalp, the legs, the hands, and the feet are seldom affected. And still more seldom the bones, the periosteum of the vertebræ, the spinal canal, or the tongue; but fatty tumors have been observed in all these situations. The disease is rare in the abdomen, but I once removed a large fatty mass from the interior of the sac of a hernia, where it lay, not adherent to the sac, but attached by a long pedicle, probably to the omentum. It had descended suddenly, and had given rise to symptoms resembling those of strangulation of the intestine, but somewhat less acute.

Lipoma may occur at any age, but is much more common in adults than in children. A few examples of congenital lipoma have been described, notably a huge lipoma of the tongue which proved fatal a few days after birth.[1]

The comparative rarity of lipoma during childhood and the unusual situations it affects in children, together with certain peculiarities of structure, particularly the presence of a fibrous pedicle in many of the tumors, encourage the belief that these growths are really rather fibrous tumors which have been transformed in whole or part into fat.

Characters and Course of Lipomata.—The *characters of a subcutaneous fatty tumor* are usually sufficiently decided to permit of ready recognition. The outline lobed and circumscribed, the surface slightly dimpled, the consistence so soft as almost to exhibit fluctuation, the natural condition of the skin, the absence of all signs of inflammation, and the free mobility of the tumor on the subjacent parts, render the diagnosis sure and rapid. In fact, the only disease which is liable to be mistaken for it, is a chronic abscess, and this may be distinguished by the absence of lobes, the certain fluctuation, and the less mobility of the swelling, even when there are no signs of inflammation. When the symptoms of fatty tumor and abscess are very evenly balanced, a puncture with a grooved needle or fine trocar and canula will aid the diagnosis. In certain situations the characters of lipoma are not so distinctive. The thick integuments of the scalp conceal the lobulation of the tumor, and lend to it a greater firmness than it ought naturally to possess. Lipomas of the nape of the neck are often composed of very tough fat, containing a large proportion of fibrous tissue, and instead of being circumscribed, lobed, and movable, are fixed and ill-defined. This often appears to result from the pressure of a basket or some heavy object frequently resting on this portion of the trunk.

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[1] Arnold, Virchow's Archiv, Bd. 50, S. 482.

Though most fatty tumors appear to be spontaneous in their origin, certain of them can be clearly traced to injury, or frequent irritation, or pressure. The lipomas of the nape of the neck are an example of this, and some of the growths about the shoulders are attributed to the rubbing of a strap or of a brace, while persons who ride much are occasionally the subjects of fatty tumors of the buttocks.

The growth of a fatty tumor is usually very slow, so that in ten years it may not have attained the size of a fist; but some fatty tumors increase in size more quickly, and in the course of many years may produce enormous masses, weighing several scores of pounds. These huge growths are rarely seen at the present day, for people submit more readily to operations since the introduction and constant use of anæsthetics. It may be the same reason which renders the shifting of fatty tumors so rare that no case has been of late recorded. Cases have formerly been described in which a tumor has moved from its original seat to one far lower on the trunk, apparently slowly sliding in the subcutaneous tissue, because the loose attachments of the tumor have been too weak to sustain the burden of its weight.

Although a fatty tumor usually forms a lobed and flattened mass, it is in some instances more prominent and globular, and is sometimes constricted at its base, and attached to the body by a long and narrow pedicle.

Fatty tumors apparently are rarely inherited. They are in some persons multiple, rarely symmetrical. The multiple tumors grow usually in the subcutaneous tissues of the arms and thighs, but may appear in considerable numbers on the trunk and the extremities. They are not usually simultaneous in origin, and often occur at intervals of many months or years. They seldom reach a large size, and may remain stationary during many years. Five years ago, Mr. Callender removed one of a number of fatty tumors from the forearm of a woman who, twenty years previously, had been treated by Mr. Liston for the same disease. During these twenty years a few more tumors had appeared, but the older growths had altered very little in size.

Fatty tumors are very seldom tender, and not often painful; but occasionally a solitary tumor, or one of a large number of multiple growths, is the seat of exquisite pain. The slightest touch, or the pressure of the clothes, suffices to produce a severe paroxysm of pain, not necessarily confined to the tumor, but more often radiating widely around it. These are some of the "painful subcutaneous tumors," which were formerly described as a separate class of growths. But, since these painful subcutaneous tumors vary much in structure, their small size, their exquisite sensibility, and their tendency to affect the subcutaneous tissue, are not sufficiently weighty reasons for separating them from tumors which are not noticeably painful. The painful fatty tumors are, for the most part, very small, and soon cease to grow; but they do not differ in appearance or in structure from other fatty growths. Their sensibility has been attributed to their containing nerve-fibres, but is much more probably due to pressure upon a nervous twig. With removal of the tumor, the distress which it occasions ceases.

Appearance after Removal.—The appearance of a typical fatty tumor, after removal, is that of a lobed mass of soft and yellow fat, inclosed in a thin, firm, fibrous capsule, from which septa pass into the interior of the growth, separating and confining its lobes. But, as the clinical characters vary, so may the appearance of the tumor. The firmer growths are composed of a tougher adipose tissue, in the form of numerous tiny pellets, and of a large quantity of fibrous tissue. Many of the lipomas are not separate, encapsuled tumors, but continuous outgrowths of adipose tissue, whose boundaries are indistinguishable. In fact, a certain limited area of the patient's tissues has become obese, and if the condition were more extensive, and affected the whole body, it would be regarded merely as excessive corpulence. The *microscopic characters* of lipoma resemble those of normal adipose tissue, but the fat-containing cells are generally of larger size. (Plate XVIII. Fig. 1.)

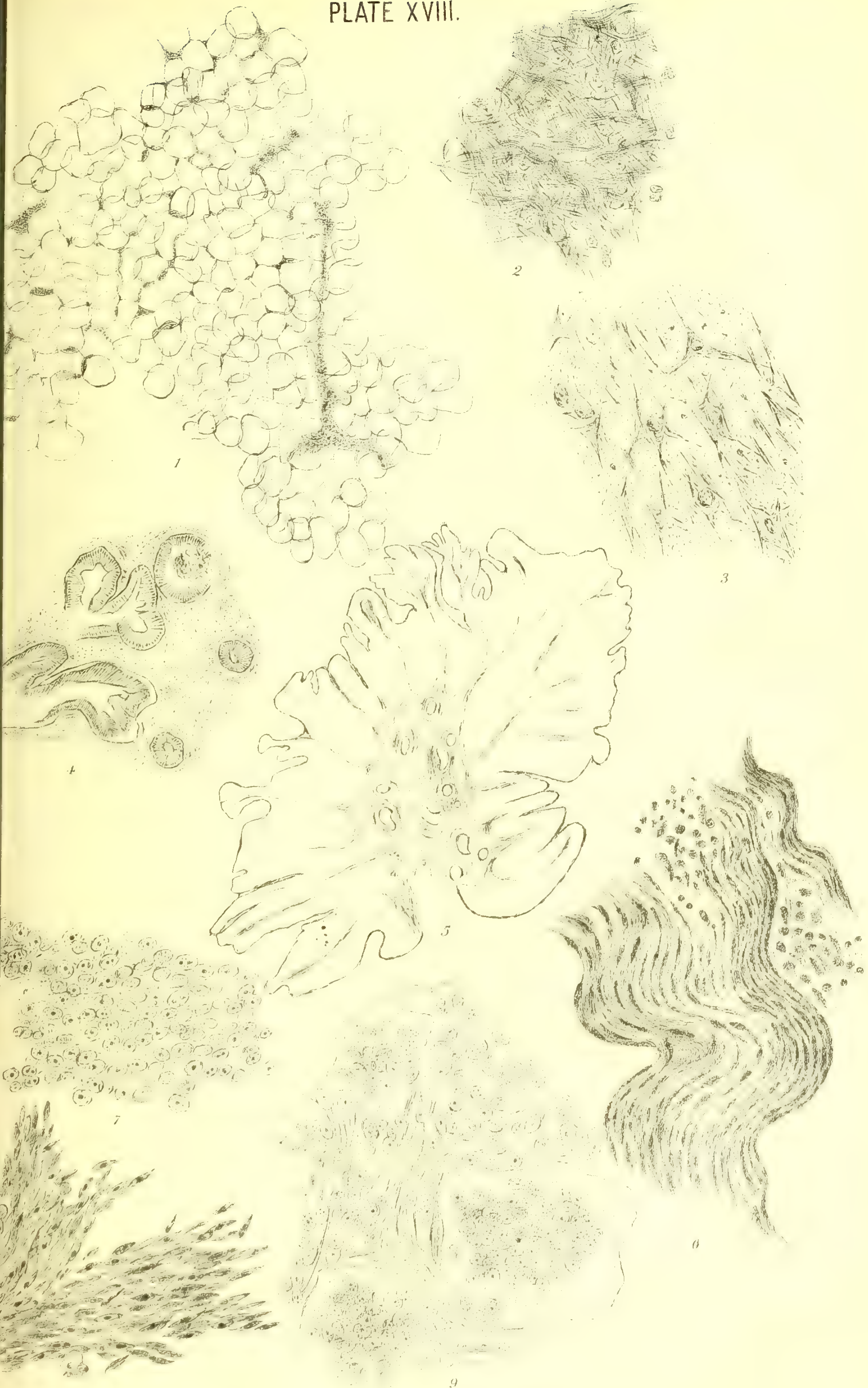
Metamorphoses and Combinations.—Fatty tumors are not liable to many degenerations, nor do they tend to become organized. Occasionally they soften and become in great part fluid by mucous degeneration; or mucous cysts are formed within them. This transformation of adipose to mucous tissue may be regarded as a retrograde step, in which the perfectly-developed tissue resumes its immature condition. Calcification of lipomas has been described, but the calcification is probably always of the fibrous septa of the tumor, or of masses of fibrous tissue included in it. In the Museum of St. Bartholomew's Hospital are several examples of these calcified lipomas, two of which contain central masses of calcified material, while in two others the fibrous septa of the tumor have undergone calcareous transformation.

The mingling of fatty with other tissues is not very rare. Thus, fibrous tissue is invariably present in a fatty tumor, and in the firmer sorts is often present in almost equal quantity with fat. It is probable that some of the tumors which are partly fatty, partly mucous, are rather composite tumors than due to the metamorphosis of a perfectly developed fat. A few rare examples of fatty tumor contain an undue proportion of vessels, and are almost nævoid. The term *lipoma telangeiectodes* has been applied to them, but it is an unwieldy and unnecessary term. Such tumors appear to be in reality degenerated nævi. I have seen two such beneath the muscles over the ribs of young subjects, and a third diffused among the normal structures of the sole of the foot of a little girl, in whom it was the seat of extreme pain, which necessitated its removal by a troublesome dissection. Some of the congenital fatty tumors contain tissues which certainly would not have been expected in them. Thus, bone has been found in one or two instances; and a small rounded tumor removed by Mr. Smith from an infant's perineum, where it sat behind and closely resembled the scrotum in size and shape, and in the wrinkling of its surface, contained a long slender stalk of hyaline cartilage.

The tumors which are large and pendulous are liable to inflammation and ulceration. Over some of them the skin sloughs in large areas, leaving foul ulcers of forbidding aspect, which may even be the source of troublesome hemorrhage. Fatty tumors are, however, not usually very vascular.

Treatment.—The *treatment* of fatty tumors is generally very simple. A solitary tumor, if it be growing, should be removed. If it be lobed and not

PLATE XVIII.



Microscopic Appearances of Tumors.

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adherent to the surrounding structures, it may be quickly shelled out through a single incision. If it be more adherent, it may require to be dissected out. When the growth is pendulous, a portion of the integument covering it should be removed, and when this is ulcerated, the ulcers will naturally be included in the piece taken away. The painful subcutaneous fatty tumors, even if they are not increasing, should be removed, for the pain ceases with the removal of the tumor. The removal of a fatty tumor is attended with very little hemorrhage, unless the tumor lies beneath the scalp. Recurrence after removal is very rare, only a few cases having been recorded in which such an event took place. One case has been recorded of a fatty tumor which rapidly recurred, and pursued a most malignant course, proving fatal in the course of a few months.

It is impossible to avoid the suspicion that this tumor was in truth a sarcoma or carcinoma, with which fat was largely mingled; but this is denied by the observer, after a thorough microscopical investigation. Multiple fatty tumors are not often removed, but one or more of them may be taken out if they be very inconvenient or painful.

The fatty outgrowths, which are not infrequently multiple, and the cause of great disfigurement, are scarcely amenable to operation. They sometimes, but rarely, diminish or disappear under the long-continued administration of liquor potassæ.

FIBROMA OR FIBROUS TUMOR.

A tumor composed of fibrous tissue may form either a very firm, almost hard, mass, or a tumor so soft as almost to fluctuate. The soft growths include many of those which were formerly classed apart as "fibro-cellular" tumors. Again, fibrous tumors may be circumscribed or diffuse; in the one case forming separate masses, generally encapsuled, in the other case producing hypertrophy of tracts of tissue. Continuous outgrowths of fibrous tissue, similar to the continuous outgrowths of fatty tissue, also occur.

CHARACTERS AND COURSE OF FIBROMATA.—Fibrous tumors may originate in the connective tissue of almost any region of the body, but they occur most frequently in connection with the skin and subcutaneous tissue; the nerves (neuroma); the female breast, the vulva, and the uterus; the periosteum, fasciæ, and intermuscular septa; the upper and lower jaw (epulis); the external ear. In the skin they are usually firm and circumscribed growths, seldom of large size. In the nerves they are for the most part circumscribed and firm, but occasionally form diffused and irregular outgrowths either of the peri- or the epi-neurium. The fibrous tumors of the breast are the most common of the innocent growths of that part, and are almost always firm, circumscribed, and impure from the mingling of other tissues with the fibrous tissue. The tumors of the vulva are among the best examples of soft fibro-cellular tumors, and are generally continuous "outgrowths" of the clitoris, or more often of the labia. Those of the uterus form either firm and separate tumors, or polypoid growths which project into the cavity of the organ. The periosteum, fasciæ, and intermuscular septa usually furnish the firm varieties of fibroma; the naso-pharyngeal polypi, which are attached to the base of the skull, are probably of periosteal origin. The fibrous tumors of the jaws are almost invariably firm; many, if not all, of the epulides are of periosteal or periodontoid origin. The tumors of the ear are for the most part firm, ill-defined growths of the lobe, often excited by the presence of an ear-ring.

Every period of life is subject to fibroma, but adults are much more often attacked than children; indeed, the only structures of children which appear peculiarly liable to fibroma are the skin and subcutaneous tissue. Many of the cases of multiple fibroma—fibroma molluscum, for example—commence during childhood.

A fibrous tumor usually grows slowly, but may in the course of years attain a considerable size and a weight of many pounds. Large size is, however, by no means usual; many of the fibromas tend rather to affect a very small size. Thus, in the breast, unless the tumor be complicated with cysts, it is generally not much larger than a walnut or a Tangerine orange. The epulides are generally very small. The tumors of the skin and nerves are insignificant as regards their size. The growth of fibrous, like that of fatty tumors, is prone to be unequal, and sometimes intermittent during long periods of months or years.

Appearance after Removal.—As might be expected, the appearance of fibrous tumors varies exceedingly, and depends in great measure on their origin and situation. The firm kind is usually encapsuled, cuts firmly or toughly, and almost with a gritty section, and presents, when cut, a glistening aspect. The naked eye can easily discern fibrous bands traversing the section in various directions. In some tumors these bands are disposed irregularly; in others they assume the appearance of concentric laminæ arranged around one or many central points; and in others, again, they form whorls around many centres. Some of the firmest tumors, which are as hard as cartilage, present on section an almost homogeneous aspect, so closely are the tissues set of which they are composed. Some of the soft fibromas, on the other hand, resemble mucous tumors, and are almost as soft as jelly. Such tumors, after removal, exude clear fluid, which slowly oozes from them, until at length there remains only a soft, pulpy tissue, less than one-fourth the size of the original mass. These tumors, those of the vulva especially, are sometimes of considerable size.

As in the macroscopic, so in the *microscopic characters*, there is a marvellous variety in fibrous tumors, not only between the hard and soft tumors, but between different specimens of hard fibroma. Even the same tumor may exhibit several kinds of fibrous tissue side by side, and the proportion of cells to fibrous tissue is liable to considerable variation. The form of fibrous tissue most frequently observed is, perhaps, fibres larger and coarser than those of typical, wavy, fibrous tissue, arranged to form parallel, but not wavy bundles. The bundles cross each other, anastomose, and interlace, but often leave fissured spaces, sometimes of large size. Between the bundles, or even between the individual fibres, there are frequently a homogeneous or finely granular connecting substance, and oval nuclei or cells. In some instances the cells are spindle-shaped or stellate. The fibrous tumors of the breast and those of the lower jaw (epulides) almost invariably contain many large oval nuclei or nucleated cells. A few tumors consist almost entirely of broad bands rather than fibres—bands as broad as narrow bundles of the wavy tissue. Some fibromas, especially those of the skin and subcutaneous tissue, are composed largely of the typical wavy tissue, containing larger and more numerous cells than normal, wavy, fibrous tissue. In some of the fibromas of the breast and periosteum, the tissue consists of a vast number of delicate fibrils, not arranged in bundles, unless it be in very narrow bundles, and disposed in strangely irregular fashion. Of this more unusual form a sketch (Plate XVIII. Fig. 2) is introduced to show the extreme confusion of the disposition. Another very unusual form I have seen in a tumor of the forearm of a young girl, where it had grown some years previously in, or close to, the seat of a slight injury. The tumor was quite hard, about the size of a large walnut, perfectly inclosed in a thick capsule. It appeared to be entirely built up of flat, irregularly-shaped bands, whose length only slightly exceeded their breadth. Placed at a little distance apart, these bands gave off from every side—or, rather, split up into—coarse radiating fibres, which, joining or interlacing with the fibres of the surrounding bands, formed a delicate network. The design thus worked is very ornamental and very difficult correctly to trace or copy. The soft fibromas have more often the structure of loose areolar tissue, in the meshes of which is contained the serous fluid which oozes away in such abundance after removal of the growth. They invariably contain cells, but generally not in larger proportion than many of the hard tumors. Elastic fibres are present in these soft fibromas, wound round the bundles of white fibres, and many of the hard fibromas contain elastic fibres, but the proportion is in most tumors very small. The fibromas are not usually very vascular; the vessels are provided in most instances with true vessel walls. The varieties of structure exhibited by fibromas of the same region, and apparently of the same tissue, have led Recklinghausen to the conclusion that the difference in their structure depends on the fact that, even when they appear to arise from the same tissue, they really arise from different tissues, or from different layers of the same tissue. In this way he accounts for the marked differences which exist in the structures of fibromas, apparently of a similar origin, in cases of multiple fibroma—assuming that the structure varies according as the tumor arises, now from the reticular layer of the skin, and now from the covering of the nerves.[1]

METAMORPHOSES AND COMBINATIONS.—The *metamorphoses* to which fibrous tumors are subject are not many; they may, however, become partially calcified or even ossified. I have seen one small tumor, on the back of a young man, completely encased in a thin shell of bone. Small portions of a fibroma may, too, undergo fatty or caseous degeneration. But the *combinations* of fibrous with other tissues are numerous. Thus bone, cartilage, fat, mucous tissue, gland-tissue, muscle, vessels, and sarcomatous tissue all occur in combination with fibrous tissue. It is of course doubtful how far many of these mixed tumors are to be regarded as in reality combination tumors. Some of them are unquestionably examples of transformation of tissue. The combinations with sarcoma, for instance, are undoubtedly in many cases organizations of sarcoma into fibrous tissue. Large vascular tumors (nævi) occasionally become less vascular and more fibrous with increasing age, and are then said to have undergone fibrous degeneration. But, of the mingling of fat with fibrous tissue, and of gland-tissue with fibrous tissue, there can be no doubt. The former was described in the section on fatty tumors; the latter occurs with great frequency in the breast. It occurs, too, in the parotid and other glands. The proportion in which the two structures are mingled varies in different tumors; the fibrous tissue may predominate, or the gland-tissue may be most abundant, and, as one or the other appears the more important element, the tumor may be termed an adeno-fibroma or fibro-adenoma.

Fibromas, like lipomas, are subject to inflammation and ulceration, but these are rare events, and occur only in tumors of considerable size, or in growths which have been greatly irritated or injured.

Cysts are occasionally found in fibrous tumors, but they are almost invariably due to the presence in the tumors of structures other than fibrous. The cysts in a cystic fibroma of the testis, for instance, are formed in connection with the glandular structures, and are, so to speak, independent of the fibrous tissue. The same remark applies to the cysts in cystic fibromas of the breast. In neither case do the cysts depend upon the fibrous character of the intervening tissue, for they may occur equally, whether this tissue be fibrous or sarcomatous. Cystoid cavities are, in some rare instances, formed owing to mucous transformation of the fibrous tissue, or to the combination of fibrous with mucous tissue.

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[1] On Multiple Fibromas, 1882.

Fibrous tumors may occur either singly or in numbers. Multiple fibromas grow in the uterus, in the skin and subcutaneous tissue, and on the nerves. Those of the skin and subcutaneous tissue, and the tumors of the nerves, are in some persons very numerous; they may exist in hundreds. Some of their relations and characters are so peculiar that they deserve remark. They commence in many instances in childhood, or even during infancy. They increase in size for the most part slowly, but there seems scarcely a limit to the number which may be produced. They are usually restricted to the tissues mentioned above, but occasionally affect tissues nearly allied in their disposition, the submucous tissue for example. The large majority of the tumors remain exceedingly small, even when their existence for forty or fifty years has been established. In the monograph already mentioned, Recklinghausen has given an admirable account of the structure of these tumors in two patients. They were decidedly fibrous, but their intimate structure differed somewhat according to the precise nature of the structures from which they were derived. Most of the multiple fibromas of the skin and nerves are hard, but some are quite soft. To certain cases of the latter variety the term *fibroma molluscum* has been applied, partly on account of their soft consistence, partly, I believe, on account of the resemblance of many of the cutaneous tumors to those of *molluscum contagiosum.* The appearance of the larger soft tumors of fibroma molluscum resembles that of the soft fibro-cellular tumors. Microscopic sections, however, exhibit a structure which is very different from that of most fibrous or fibro-cellular tumors. They are composed in great part of trabeculæ of cells containing vessels, and inclosing spaces filled with fluid. The cells vary much in shape and size; many of them are spindle-shaped or stellate. But cells of a very different character are sometimes seen among them, or in the fluid—round or oval cells with a double contour, nucleated, and closely resembling cartilage cells. With the tumors of small and moderate size in this disease are not uncommonly associated huge outgrowths of connective tissue covered with thick and roughened skin, which hang down around the patient's body in a great fold or folds.[1]

Symptoms and Diagnosis.—The clinical characters of fibroma vary according to the situation and variety of the tumor. Thus the tumor may be extremely firm, nay, hard; or extremly soft, and even fluctuating. It may be very movable, or immovably adherent; it may be perfectly circumscribed, or diffused, and indistinguishably blended with the tissues of the part in which it grows. And yet the diagnosis of fibroma is not, for most examples, difficult. For, although the clinical characters of all fibromas, taken collectively, are subject to wide variation, the characters of the fibromas of each part in which they commonly occur, are generally decidedly impressed. In the breast, for example, the fibrous tumors are generally small, perfectly circumscribed, nodular, very freely movable, detached or almost separate from the gland, of rounded shape and slow growth, painless, and not adherent to the skin or muscle; they attack usually the breasts of young women. They can only be mistaken for adenomas, an error quite unimportant; or for sarcomas, from which they may be distinguished in most instances by the quicker growth of the latter and their less mobility. In the lower jaw, again, the fibrous tumors assume generally the form of epulis, are small, smooth, covered with red mucous membrane, fixed closely around the neck of a tooth or stump, slowly growing, and painless. They must be diagnosed from giant-celled or other forms of sarcoma, which are infinitely more rare, grow much more quickly, attain a much greater bulk, and tend to ulcerate. The giant-celled sarcomas are rare in the form of epulis, but, when they do occur, often closely resemble fibrous epulides. But they are usually of darker color and quicker growth. The large outgrowths of the labia and other portions of the vulva can scarcely be confounded with any other kind of tumor. Their soft and almost doughy consistence, their large size, but slow growth, and the wrinkled, brown, thickened skin, covering and intimately adherent to them, are pathognomonic of their nature. Some of those of the labia certainly are much firmer to the feel when they are prominent, but not loose or dependent masses, but the thickened and altered skin over them, to which they owe much of their firm feel, is characteristic. In the uterus, I believe, they cannot be distinguished from myomas; and this holds good after removal until a microscopic examination has been made. The soft fibrous polypi of the nostrils are, too, indistinguishable from mucous polypi; clinically, the diagnosis is unimportant; pathologically, it is probable that the two diseases are intimately related, and that one is but a modification of the other. In the skin and subcutaneous tissue, and in the nerves, the diagnosis may be very difficult, especially between fibroma and sarcoma. The firmer feel of fibroma, its slower growth, and the comparatively small size of the tumor, are the most important features.

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[1] [These are the growths to which the terms *dermatolysis* (Wilson), *pachydermatocele* (Mott), and *eiloides* (Warren), have been applied.]

The diagnosis of multiple fibromas from multiple sarcomas is not usually beset with difficulty. The course of the one disease is often lifelong, of the other only a few months, or two or three years; the sarcomas often form large tumors, the fibromas only rarely—in such cases, for instance, as fibroma molluscum. Fibrous tumors *in* the upper and lower jaws are usually characterized by their slow growth, and by the freedom of the skin and other surrounding structures from infiltration.

In connection with the fibromas which occur on nerves, it may be mentioned that, not only are they usually free from pain, but even firm pressure on them fails to elicit signs of pain. This is the more remarkable because fibrous tumors furnish the typical examples of the "painful subcutaneous tumors," and many attempts have been made to prove that the pain and tenderness, of which these tumors are the seat, are due to the presence of a nerve or nerves within them, or to a large mingling of nervous tissue with their structure. But repeated examinations have failed to detect the presence of either of these conditions. And experience of fibrous tumors on nerve-trunks, whether large or small, has shown that a tumor which contains a nerve, or lies between its fibres, is not necessarily or even usually painful. The cause of the pain in these "painful subcutaneous tumors" must, therefore, be sought in some special and peculiar relation of the tumor to the sensory nerves. The clue may probably be found in the bulbous condition of the nerve-ends, in certain painful stumps, in which the presence of a larger bulb than usual is the source of a similar exquisite tenderness to that existing in the painful tumors. The tumors in the stump lie at the cut ends of the nerves, and the theory which is suggested by this circumstance is, that the painful tumors are formed in connection with the terminations of nerves, or on the proximal extremities of sensory nerves which have been divided, perhaps by accident, or by the growth of the tumor.

Prognosis.—The prognosis of a fibrous tumor is unquestionably favorable. Its presence may be distressing on account of pain, or inconvenient by reason of its situation or its bulk. But even multiple fibrous tumors in prominent situations may be borne with very little distress. One of the patients described by Recklinghausen was the subject of several hundred tumors, many of which had originated during childhood; yet she lived to be more than fifty years of age, was twice married, and bore eleven children. Small fibrous tumors of the breast are often permitted to remain untouched during many years, without danger or detriment to health. Huge outgrowths of the vulva frequently exist for years without treatment, partly because of the slight annoyance which they occasion, partly on account of the modesty which induces a woman to conceal as long as possible the existence of such a tumor. The prognosis of a fibrous tumor may, however, be complicated or falsified owing to misconception. A very shrunken, scirrhous carcinoma, or mixed fibroma and sarcoma, or, more probably, a fibrifying sarcoma, may be mistaken for a fibrous tumor, and on this faulty diagnosis an equally faulty prognosis may be based. From such errors as these it has appeared as if certain fibrous tumors were capable of exhibiting characters of malignancy, and a group of "malignant fibrous tumors" was formerly described to include cases such as these. These cases may now more justly be regarded as examples, not of malignant fibrous tumors, but of carcinomas, or, much more frequently, sarcomas, which have been, in great part, transformed into fibrous tissue.

Treatment.—As to the treatment of fibrous tumors, they may be removed if they are sources of pain or inconvenience, or if they are increasing quickly. For most of them the knife is the best instrument for removal, but the epulides may need the gouge, and the fibrous polypi of the uterus may be more safely removed with the écraseur. The soft fibrous polypi of the nose may be best taken away with the galvano-cautery; or, under chloroform, the portions of bone to which they are attached may be cut through, and, together with the polypi, removed, in order to prevent recurrence. For, although recurrence does not take place after complete removal of a fibroma, the tumor slowly grows again if the removal has not been complete. The outgrowths of the vulva, in spite of their enormous size, may be removed with a minimum of danger and difficulty. The blood-supply is inconsiderable, and the vessels may be easily secured. Indeed, the disproportion, in most of these large tumors, between the size and number of the vessels and the bulk of the tumor, is so striking that it is difficult to conceive how so large a mass can be nourished by so small a blood-supply. The explanation may probably be found in the low vitality of the tumor, and in the fact that the nourishment which it receives is solely for its maintenance, for it neither expends its force in action nor supplies material for further use in the economy.

Chondroma or Cartilaginous Tumor.

A tumor composed of cartilage may occur either as a hard or as a soft mass. The most typical examples of cartilaginous tumor are those which occur in connection with cartilage and bone, all of which may be regarded as homologous on account of the close relations between bone and cartilage. Of cartilaginous origins, the septum nasi is probably the most frequent; but small chondromas grow also from the larynx. The bones which produce chondromas are many of the long bones—the femur, tibia, clavicle, humerus, bones of the forearm, and phalanges of the fingers and toes; and some of the flat bones—the os innominatum and the scapula. They grow also in connection with the jaw bones, the upper more often than the lower.

The number of the chondromas may be largely augmented if the cancellous exostoses which are coated with a layer of hyaline cartilage are classed among them as ossifying tumors, instead of, as is the present custom, among the osteomas. The chondromas of the long bones occur usually near the extremities of the bones, and are more often of subperiosteal than of central origin; those of the phalanges usually arise in the interior of the bones, which are blown out by them until only a thin shell of compact tissue covers the tumor, or until the tumor reaches even to the periosteum. But the chondromas are not limited to the cartilages and the bones. They occur almost as frequently in certain parts which contain neither cartilage nor bone; as in the substance of certain glands—the parotid, submaxillary, sublingual, and lachrymal glands, and the testicle—and, very rarely, in the subcutaneous tissue. In the glands it is, of course, supposed that they originate in the connective tissue, not in the essential elements of the gland.

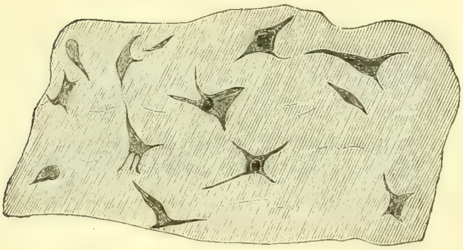
CHARACTERS, COURSE, ETC.—Young persons are much more frequently the subjects of chondroma than are older persons. Some chondromas are indeed congenital. The large majority of them commence during childhood or young adult age. This is scarcely surprising when they arise from bone and cartilage, for the new formation of cartilage in the growth of both tissues occurs so largely at this period of life, that an overgrowth or outgrowth of cartilage in cartilage-producing situations may be regarded as a not unnatural event. The power of producing cartilage, however, is not limited to the earlier periods of life, although it becomes less strong with advancing age. Many of the cartilage tumors of the middle and later periods of life are not specimens of simple chondromas, but of sarcomas which are chondrifying.

Chondromas are almost always slow-growing tumors, and the pure examples do not often attain considerable size. Some of the tumors of the long bones, and of the scapula and pelvis, however, reach a large size in the course of years of growth. The manner of growth is, I believe, always by additions to the surface, except, perhaps, in the case of certain tumors of the glands, the testis especially, which enlarge, in part at least, by increase of the separate fragments of cartilage of which the tumor is composed.

APPEARANCE AFTER REMOVAL.—The appearance of a mass of cartilage is so well known that the naked-eye appearance of a cartilaginous tumor may seem scarcely to require description. But, although many of the tumors have the general appearance of an almost homogeneous mass of hyaline cartilage, this is not true of all. Some of them are far softer than others, and are almost gelatinous. Some are tough and less translucent. And while many, those of the bones especially, are tolerably homogeneous masses, interrupted only by bands of fibrous tissue, as if interwoven with the cartilage, a certain number of them, those of the testis above all others, are composed of small nodules, tubes, and cylinders of cartilage, separated and bound together into a single tumor by a thick matrix of fibrous tissue, in which the vessels lie. One tumor I have seen in a woman between twenty and thirty years of age, situated in the subcutaneous tissue of the arm a little below the axilla, which consisted of a large number of small nodulated fragments of cartilage, disconnected, but fitted together like the pieces of a dissected puzzle, and lying closely packed in the interior of a fibrous sac or capsule. Cartilaginous tumors are almost invariably circumscribed, and generally encapsuled. The capsule is in many instances formed by the compact layer of a bone, or by the periosteum, but when the tumor lies in an organ such as the parotid gland, is usually such a fibrous capsule as surrounds a fibrous or fatty tumor. The surface of the growth is almost always nodular or tuberous.

The *microscopic characters* of chondroma are seldom the typical characters of normal cartilage. In the first place, two or more varieties of cartilage may be present in the same tumor, and, instead of forming distinct and separate parts of the tumor, may be intimately blended in all parts. Thus, hyaline and fibrous cartilage may be mingled, and, with them, areas of cellular cartilage may be blended. In the second place, the cells usually differ from those of normal cartilage in their larger size, their greater number in each cell-cavity, and their irregular disposition in the matrix. The spindle and stellate cells so frequently described are not usually observed in the hard chondromas, and their presence in the soft varieties may justly be explained by the close relation which subsists between soft cartilage and mucous tissue, of which mention will presently be made. Cellular cartilage, such as that which forms the chorda dorsalis of the embryo, is rare in tumors, and probably never forms a large proportion of their structure.

Fig. 761.



Chondroma of lachrymal gland. × 280.

Metamorphoses and Combinations.—Chondromas are very prone to undergo partial ossification or calcification. The doubt has already been expressed, whether the cartilage-capped exostoses ought not more correctly to be termed ossifying chondromas than osteomas. But, setting these aside, the ossification or calcification of cartilaginous tumors, both of the hard parts and of the soft, is quite an ordinary occurrence. The metamorphosis affects usually the central portions of the tumor, and, in calcification, the lime salts are deposited in the matrix of the cartilage. In tumors consisting of numerous separate pieces of cartilage, the central portion of each piece may thus be calcified. This was so in the case already alluded to of tumor in a woman's arm. Ossification and even calcification of chondromas seem to belong so closely to the natural order of occurrences, that they excite scarcely a feeling of curiosity. But there is another metamorphosis of cartilage, by no means uncommon, of which no such satisfactory explanation can be offered. In this, the mucous transformation, the cartilage grows softer and more translucent, until it may be so altered as to form a gelatinous material or even viscid fluid. Probably only the hyaline cartilage thus degenerates, but large masses of it may be liquefied, and the liquid, lying in the interior of a solid tumor, gives rise to the appearance of a cyst. Many cysts, or rather cystoid cavities, of this nature, may be found in a large chondroma. The contents may vary in color, consistence, and clearness. But they are generally yellow or yellowish-white, viscid, like synovia, and quite translucent. A microscopical examination discovers numerous spindle-shaped or stellate cells, with long, delicate processes, formed by transformation of the cartilage-cells or nuclei, or perhaps rather derived by descent from the cells of the cartilage than due to transformation. The liquid is as probably due to a metamorphosis of the matrix.

The hard chondromas yield chondrin in chemical analysis; the softer chondromas, and those which are actually liquefied, yield mucin.

Cartilage is frequently combined with other tissues in tumors. Bone, fibrous tissue, gland-tissue, and sarcoma-tissue, all or severally may occur in combination with cartilage. Of the last of these it would generally be more just to say that the sarcoma-tissue has been organized into cartilage; and of the first, that the bone is the result of organization in the cartilage. But the minglings of fibrous and gland-tissue with cartilage are true combinations. The former is observed in almost all chondromas, whatever be their situation; the latter is only found in chondromas originating in glands, and is especially frequent in the parotid. Of such tumors, it may of course be doubted whether the gland tissue is not merely a remnant of the natural structure of the organ. But in some instances there are characters which lead to the belief that a new formation of gland-structures occurs, similar to that which takes place in many tumors of the breast.

Chondromas are rarely the seat of inflammation, and do not often ulcerate.

Diagnosis.—In most instances the characters of chondroma are very clear, and the disease need seldom be mistaken. The extreme hardness of the hard variety, the nodular or tuberous contour, the slow and painless growth, and the situation of the tumor on bone or cartilage, or in a gland, are sufficiently distinctive. Multiplicity in certain situations is another important feature of the disease. The phalanges of the fingers and toes are not uncommonly the seat of multiple chondromas, of which there may be two or three growing from each finger. Whether these phalangeal tumors are single or multiple, and even when they are of central origin, and so large as completely to destroy the bone in which they grow, they seldom affect the joints, which may remain for years intact, although their action is interfered with by the size and situation of the growths.

An osteoma may be mistaken for a chondroma, but the mistake is unimportant. Very similar as are the characters of the two diseases, the diagnosis is, nevertheless, in many instances very simple; for the tumors generally select very different seats. Chondromas are frequently found upon the toes and fingers, osteomas rarely upon any save the last phalanx of the great toe; multiple osteomas of the ribs and long bones are not unusual, multiple chondromas, except of the hand and foot, are rare; chondroma of the salivary glands is of tolerably frequent occurrence, osteoma so rare as to be almost unknown; osteoma seldom originates in any of the soft parts, but is much more common in connection with the bones than is chondroma. A fibrous tumor is occasionally taken for a chondroma when it is exceedingly firm, and contained within a very tightly-fitting capsule. Here, again, the mistake may usually be avoided by attention to the seat of the disease. The most important and the most frequent mistakes are made between chondroma, whether soft or hard, and sarcoma, for the latter affects the same situations as the former, and may consist in large part of cartilage. In certain situations, liable to both diseases, chondrifying sarcoma much more frequently occurs than pure chondroma; the long bones and the testis may be adduced as examples. It is of extreme importance to avoid an error of diagnosis, because the prognosis in the two cases is so widely different. The unequal consistence and the rapidity of growth of sarcoma are often the only distinctive features; but the unequal consistence is not quite reliable, for even this sign may be observed in some of the soft or softening chondromas.

Prognosis.—The prognosis of an uncomplicated cartilaginous tumor is favorable, for the tumor is quite innocent. The gravity of the disease is heightened, naturally, by large size or multiplicity of the tumors, or by the importance of the organ which is attacked. Thus, multiple cartilaginous tumors of the fingers may necessitate amputation of the hand, and chondroma of the testis may lead to destruction and removal of the organ. But there is little likelihood of local recurrence of a chondroma, and no tendency to affection of the lymphatic glands, or to dissemination of the disease. I am aware that this doctrine is not quite in accordance with those which have hitherto been taught. For, while it has been admitted that cartilaginous tumors are innocent, the admission has been modified by adding that certain of them are malignant, and examples have been cited of cartilaginous tumors of the testis and the bones, in which the disease has attacked the lymphatic glands, the lungs, and other organs, and has rapidly proved fatal. But, as I have pointed out elsewhere,[1] this statement rests on an error of diagnosis; for the tumors which pursue this irregular course are chondrifying sarcomas, not chondromas.

Treatment.—Removal with the knife is the treatment most appropriate to most chondromas. Even a small tumor of the septum nasi requires removal, on account of the partial or complete obstruction of the nostril which it causes. Chondromas of the salivary glands may usually be dissected out without seriously damaging the gland, provided that they are of small size. Those of the lachrymal gland and testis more often necessitate complete removal of the organ. Multiple chondromas of the fingers may and should be left uninterfered with as long as the hand and fingers can be used; but if their weight, and size, and number, incumber the hand so as to render it not only useless but a burden, amputation at the wrist or forearm must be performed. When the affection is limited to a single tumor of a finger, a very different course may be pursued. Even the finger may be preserved, and remain a useful and sightly member, after the tumor, large in relation to the bone in which it lies, has been removed. One case I can call to mind at present, in which a tumor was scooped out of the interior of the second phalanx of a young lady's finger, five or six years ago. At the last report (December, 1882) she was well, had never suffered from recurrence, and was able to use the finger easily; yet the tumor occupied the interior of the phalanx from end to end, was so large that it produced great unsightliness, had destroyed all the bone, with the exception of a very thin shell at the back and sides, and was so friable in parts that separate fragments required to be scooped out after the removal of the main mass, so that there appeared a danger lest some minute fragment had been left behind. From this and similar cases it is clear that an attempt should be made, wherever it is feasible, to remove the disease, leaving the part from which it grows.

Osteoma or Osseous Tumor.

An osteoma is a tumor composed of bone, either cancellous or compact. Bone tumors are not rare; they grow almost exclusively from the skeleton, but a few examples have been described in connection with the dura mater (separate from the skull), and even in the interior of the brain and of the eye. They are also observed occasionally in the lung and in the testis. The additamentary masses of bone which grow in the synovial fringes of joints affected by rheumatoid arthritis, scarcely belong to the category of tumors. And a similar objection may be made to the small masses of bone in tendons and aponeuroses, which are probably due to the ossification of inflammatory products.

The cancellous osteomas grow usually from the long bones—the femur, tibia, and humerus above all others; sometimes at the attachments of the muscles or tendons, but chiefly towards their extremities. They are found usually at or about the junction of the epiphysis with the diaphysis, where the increase in the length of the bone is effected. And, as they occur generally in young subjects before the full stature has been attained, it may be assumed that these naturally active parts of the bones have been excited to undue and ill-directed activity, and have consequently put forth processes or outgrowths of cartilage and bone. For these exostoses do not merely consist of cancellous bone, but are capped with hyaline cartilage, forming in some specimens a layer of considerable thickness. The question of the propriety of regarding them as cartilaginous tumors was discussed in the last section (on chondroma). The tumors which occur at the attachment of tendons are chiefly due to the ossification of a portion of the tendons. Cancellous osteomas grow also from the irregular and short bones—the vertebræ and tarsal bones; and a very favorite situation is the dorsal aspect of the last phalanx of the great toe, where they protrude beneath the nail and form small but very painful tumors.

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[1] Sarcoma and Carcinoma, chap. ii. London, 1882.

The compact tumors grow usually in connection with the flat bones and the jaws. Those which grow from the scapula and flat bones of the skull, are usually rounded and often quite smooth exostoses, rarely of large size. Some of them, which are formed of compact layers, arranged like the lamellæ of an onion around a pedicle or central stem, are so hard that they can scarcely be cut into with a saw or chisel; they have been named eburnated or ivory exostoses. The tumors which originate in the jaw-bones, and especially those of the upper jaw, often bear the character of diffused enlargements of the bones, and consist sometimes of compact, sometimes of finely cancellous bone. Although many of the compact osteomas attack young subjects, the rule is not as strict for them as for the cancellous tumors. They occur not infrequently in adults of from thirty to forty years of age.

Course of Osteomata.—The growth of osteomas is very slow. Some tumors exist for from ten to twenty years, and only attain the size of a racquet ball. It is, indeed, unusual to find a tumor, composed only of osseous tissue, of large size. Yet osseous tumors, apparently pure, have occasionally been observed of enormous size; one, of the tibia, mentioned by Sir James Paget,[1] measured a yard in circumference.

Appearances after Removal.—The *macroscopic characters* of osseous tumors are those of bone. The cancellous growths are like the cancellous tissue of the ends of the long bones, but for the most part coarser and less regularly formed. They are capped either with cartilage or with a layer of compact bone. The spaces which they contain are in some instances very large and filled with marrow. In outward form they vary much; from pedicled knobs or hook-like processes, to smooth and sessile lumps, or to rough, irregularly-shaped excrescences and masses. The surface of the larger masses is generally nodular or tuberous. They may generally be easily gouged from the bone on which they grow, and the surface left by their removal is rough and like cancellous bone. The compact growths may be so closely set that no spaces are visible, or, on the other hand, may be composed of a very fine cancellous tissue, the spaces of which can only with difficulty be distinguished. Some of these tumors form large masses of irregular shape; particularly the tumors of the upper jaw, which completely fill the antrum, and, enlarging the bone in all directions, encroach on the neighboring cavities. Both upper jaws may be affected in the same patient; and, with these, the other face-bones are, in some rare instances, the seat of irregular bony outgrowths, and the face is by this means horribly distorted and disfigured. The appearance of the features produced by this condition has been termed Leontiasis.[1] The lamellar arrangement of the ivory exostoses has already been alluded to. Occasionally, between the lamellæ, a thin layer of cancellous tissue is interposed.

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[1] Lectures on Surgical Pathology, vol. ii. p. 233.

The *minute characters* of the cancellous tumors resemble those of normal cancellous bone, but the tissue is not as perfect, nor as delicately formed. The lacunæ are less regularly disposed, and the canaliculi are not as numerous or as long as in the normal bone. The same thing may be said of the lacunæ and canaliculi of the compact bone-tumors. In these growths Haversian canals are present, but there is not the same evident arrangement of Haversian systems as in the normal bone. The ivory exostoses I have never examined; they are said to contain no bloodvessels.

METAMORPHOSES AND COMBINATIONS.—Osseous tumors are scarcely subject to transformation of their structure. Decalcification, though not impossible, seems practically seldom or never to occur. But combinations of bone with other tissues are observed, although not frequently. The large medullary spaces of some of the wide-meshed cancellous tumors are filled with embryonic or coarse fibrous tissue. Some of them are unquestionably ossifying sarcomas and ossifying fibromas. The embryonic tissue which is found in many of them does not differ in any respect, except in quantity, from the cell-tissue which naturally exists in the medullary spaces of bone under various conditions. Such tumors may therefore fairly be regarded as true osteomas, which contain a much larger quantity of marrow than is usual. Over osseous tumors which are subjected to friction, adventitious bursæ sometimes form, and these, like bursæ in other situations, may inflame and ulcerate. Otherwise, osseous tumors rarely cause inflammation or ulceration of the tissues covering them. But an osseous tumor or outgrowth will sometimes become carious or necrosed, and, being cast out, a spontaneous cure may result. This fortunate occurrence appears to be more common as a termination of large bony tumors of the bones of the head and face, than of those of other parts.

SYMPTOMS AND DIAGNOSIS.—The symptoms of an osseous tumor, like those of a chondroma, are usually very decided. The situation, fixity, and extreme hardness of the tumor, and its slow and painless growth are, in most instances, unmistakable characters of osteoma. Occurrence during youth is also a clinical character of importance. And even the shape of the tumor, although subject to great variation, is often characteristic; for pedicled growths and hooklike projections are not forms assumed by other tumors growing from bones. Multiplicity of exostoses is by no means unusual. A large number of bony tumors may grow from the ribs, femur, tibia, fibula, humerus, radius, ulna, clavicle, scapula, and lower jaw. These multiple tumors affect similar situations on each bone to those affected by the single growths. Several of them may be found towards the extremity of each long bone. They are for the most part symmetrical, occur in children, and not rarely in the children of parents who exhibit a similar condition of the bones. These multiple tumors seldom attain a large size, but one or two of them may grow out of all proportion to the rest, or may continue to increase in size after the others have reached what appears to be the limit of their growth.

The diagnosis of an osseous tumor is generally easy. The characters by which it may be distinguished from a chondroma were considered in the preceding section, and there is no other innocent tumor growing from bone or cartilage for which it is liable to be mistaken. It is, in some instances, however, difficult to decide between an osteoma and an ossifying sarcoma.

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[1] Virchow, Krankhaften Geschwülste, Bd. ii. S. 23.

The rapid growth of the latter, the large size it presently attains, its unequal consistence, and the much larger surface of bone to which it usually is attached, greatly assist the diagnosis. Osteomas are liable also to be mistaken for inflammatory affections; but the diagnosis may be made by observing that the inflammation affects the shaft of the bone rather than either end, and that the swelling is smoother, more diffused, and less prominent. Inflammatory affections of bones are, too, usually painful; osseous tumors little or not at all.

PROGNOSIS.—As the diagnosis of an osteoma is usually very easy, so is the prognosis very favorable. The tumor may be removed without fear of recurrence, provided that its base be taken away; and even this does not seem absolutely necessary to insure against recurrence. Or the tumor may be left untreated without fear that it will affect lymphatic glands or be disseminated, and, in most cases, without fear that it will increase to a large size. The malignant osseous tumors are not true osteomas, but combination tumors, or sarcomas which are ossifying. They are therefore not included in this section, but in the section on sarcoma, to which they properly belong.

TREATMENT.—An osteoma may be removed if it be increasing quickly in size, or if it cause pain or inconvenience, or threaten an important structure in its further growth. One of the most frequent reasons for removal is the pain or inconvenience produced by the frequent hitching of a tendon against an exostosis. This may necessitate the removal of a tumor of quite small dimensions from the upper end of the tibia, or from the lower extremity of the femur. Again, an osteoma of the upper jaw may be removed after many years of growth, because it grows upwards into the orbit, and causes great disfigurement or imperils the safety of the eye. The exostoses of the bones of the skull are, for the most part, beyond the reach of removal. And this, unfortunately, is the case also with many of the large, irregular, bony outgrowths of the bones of the face, which, projecting into the nostrils, orbits, or upwards into the cranium, produce horrible deformity, and damage important or vital structures. The danger incurred in the removal of these masses is usually greater than that of leaving them. Paget suggested, many years ago, that they should be exposed and treated by the application of powerful caustics in the hope of causing necrosis or caries, and ultimate sloughing of the mass. I am not aware that this plan has ever been carried out in the case of tumors of large size, nor does the operation appear likely to succeed so far as to procure the removal of any large portion of the growth. Cancellous exostoses of the long bones are usually very easily removed by means of a chisel or gouge, after thorough exposure of the base of the tumor, which should be cut away flush with the surface of the bone. The operation is not free from danger, for deep-seated suppuration is liable to occur, which delays the recovery, and may even prove fatal. The removal of a compact or ivory osteoma, even when it is easily accessible and not very large, is often exceedingly difficult on account of the extreme hardness of the tumor. The saw is a safer instrument than the chisel for such growths, especially when they are situated on the bones of the skull or face. Multiple exostoses need seldom be interfered with by operation, unless any of them are painful or very inconvenient. They almost invariably cease to grow when the stature of the patient is completed, if not earlier.

As a variety of the osteomas may be described the tumors of the teeth to which the term *odontoma* has been applied. They may be composed of cement-substance, and may grow from the fangs of the teeth as overgrowths or continuous outgrowths of the cement. Or, they may consist chiefly of a substance closely resembling the dentine of the teeth, and may attain a much larger size than in the last case, growing still usually in connection with the fangs. The largest odontomas are, however, always small tumors, the largest recorded example scarcely exceeding the size of a large walnut, while the large majority of them are scarcely more than excrescences upon the teeth. The presence of any save the largest specimens is seldom discovered until after the removal of the tooth, which may be rendered much more difficult than usual by the attachment of the tumor to the fangs.

Myxoma or Mucous Tumor.

The myxoma is a tumor composed of mucous tissue, that is, of a mucin-bearing basis or matrix in which are cells, generally stellate or spindle-shaped, with long delicate processes which anastomose with the processes of neighboring cells. (Plate XVIII. Fig. 3.) The prototype of this tissue is found, in the human subject, in the Whartonian jelly of the umbilical cord, and in the vitreous humor of the eye. It precedes also, and is probably transformed into, adipose tissue in the embryo. Tumors composed solely of this tissue in its typical condition are very uncommon, and its relations with other tissues are so close, and its combinations so frequent, that I have been tempted to wonder whether a special class of myxomas is necessary, and whether the various growths now classed under this title might not be relegated to those other classes to which each appears more properly to belong. This can, however, scarcely be accomplished at the present moment, and it will therefore be necessary to describe the class myxoma in accordance with the ideas which generally prevail.

The most typical form of myxoma is often called *hyaline*, or *pure myxoma;* but the deviations from this condition are so numerous that at least six varieties have been described: *lipomatous myxoma*, which contains much fat; *medullary myxoma*, which contains a large proportion of cells; *fibrous myxoma*, which consists largely of fibrous tissue; *cystoid myxoma*, in which are parts so fluid as to resemble cysts; *cartilaginous myxoma*, having either a firmer consistence than usual, or containing cells like those of cartilage; and *telangiectatic myxoma*, the structure of which is largely vascular. It may of course be said that these are not varieties of mucous tumor, but merely combination tumors of mucous and other tissues. If so, it is unfortunate that they have been often spoken of as varieties of myxoma. As an example of the frequency with which these varieties occur in comparison with the typical form, Dr. S. W. Gross[1] found that in seven examples, out of the cases which he had been able to collect of myxoma of the breast, only one was a pure hyaline myxoma, while the others belonged chiefly to the fatty and fibrous varieties. Mucous tumors grow in the subcutaneous tissue and the intermuscular spaces; in the female breast; in the salivary glands; in the placenta (as the hydatid mole); in the vulva; in the interior of the nose, in the form of polypi; in the nerves; and it is said even in the bones. They are far more frequently met with in adults than in children; indeed, the disease is almost confined to adult life, for, with the exception of nasal polypi, which occasionally, though rarely, are found in young subjects, the mucous tumors of other parts scarcely ever occur in children. They may form diffuse enlargements of the parts which they attack, and in the vulva they not uncommonly take the form of continuous outgrowths. But they usually produce distinct and separate tumors, which assume a rounded shape, and are inclosed in a fibrous capsule.

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[1] Tumors of the Mammary Gland, p. 101. 1880.

Appearances after Removal.—The most typical examples of myxoma present a jelly-like appearance; are colorless, or faintly tinged with yellow or gray; and are very translucent. The consistence of the tumor may vary from that of the softer varieties of cartilage to a softness bordering on diffluence. The entire tumor may appear homogeneous, or it may be divided by fibrous bands into more or less separate lobes. The characters of the varieties of the disease are very diverse; many of them may be foretold from a knowledge of the structure of the tumor. Thus, the presence of fat imparts a yellowish color and more opaque character to the growth. Large numbers of cells also cause opacity, and even so far transform the tumor that it becomes medullary or brain-like. The very vascular growths are altered and disfigured by the numerous vessels which they contain, and by numerous and often considerable hemorrhages. The pure myxomas seldom form very large tumors; indeed, it is not usual to observe a tumor as large as a man's closed fist, and the tumors of certain parts, the nose, for instance, are invariably of quite small dimensions. Their form may vary exceedingly, for, while the typical form is spherical or spheroidal, the tumors of the nose are always polypoid. Those of the nerves are generally elongated, after the manner of neuromas, and the hydatid mole of the placenta presents the grape-like appearance with which we are familiar, and which probably depends on the papillary origin of the growth.

It may easily be understood that the *minute structure* of tumors which vary so much in their general composition, is likely to vary considerably. The minglings with other tissues are so numerous that the essential structure of myxoma is, in many instances, so obscured as to be with difficulty discernible. The microscopic characters have already been described in the definition. But attention may be further directed to the homogeneous or very finely granular character of the matrix, and to the extreme delicacy of the cells, for, not only are their processes fine, and long, and delicate, but the bodies of the cells are often so vaguely outlined, and their details so indistinct, that they at once convey to the mind an impression of that fragility which constitutes one of their properties. The cells are generally furnished with a single nucleus, more clearly defined and evident than the body of the cell. The blending of mucous with other tissues is extremely interesting. Thus, the bands or individual fibres of fibrous tissue separate to form intervals of varying width, occupied by typical mucous tissue. The double-contour cells of hyaline cartilage mingle with the stellate or spindle cells of mucous tissue in a perfectly diffluent basis. Fat-cells, either single or in groups, lie scattered in meshes formed by the anastomosing processes of the typical myxoma-cells. The fat-cells are probably formed by a transformation of the myxoma-cells similar to that which takes place in the development of fat from mucous tissue. The precise method by which cartilage is transformed into mucous tissue is not so well known, but the basis-substance probably softens or liquefies, and the new cells are formed by a change in the cells of the cartilage. It is not improbable that mucous tissue is capable of being transformed in turn into cartilage, and perhaps into fibrous tissue. It is, as Virchow has pointed out, an embryonic tissue, but an embryonic tissue which may be maintained as an independent tissue. Its stability, however, appears to be of a very low order.

Metamorphoses and Combinations.—The combinations of mucous with other tissues have been mentioned when speaking of the varieties of myxoma. That most of these tumors are not combination tumors will be gathered from what has preceded. They are merely masses in which the transformation into a higher and more stable tissue is in progress, but has not been completed.

Symptoms and Diagnosis.—It is difficult to offer an account, which may be useful, of the clinical characters of myxoma. They depend, in great measure, on the situation of the tumor, but, in still greater measure, on the variety of the mucous tissue. The characters of some of the tumors are so well known that they are recognized by every student. It is only necessary to mention, as an example, the mucous polypi of the nose. But the myxomas of the subcutaneous tissue, fasciæ, nerves, vulva, breast, and salivary glands, present no distinctive characters. They may be taken for fatty, fibrous, or sarcomatous tumors, and there are no certain means by which the diagnosis can be made. Happily, an error is not of extreme importance, for the more closely the tumor resembles one or other of these, the more likely it is to be closely allied with the disease it most resembles, not only in its structure, but in its capabilities. The prognosis, therefore, which befits the one disease, is likely to prove equally true for that with which it has been confounded.

Prognosis.—As a general rule, it may be said that mucous tumors are innocent. Those which are developing into fatty and fibrous tissue, and which may be regarded rather as ill-formed, fatty and fibrous tumors, than as myxomas, are as innocent as simple fatty and fibrous tumors. But the purest forms of myxoma, in which little or no development takes place, and which, therefore, correspond closely with sarcomas in the fact that they are embryonic-tissue tumors, are as malignant as sarcomas of the same tissue or organ. Thus, several cases have fallen within my experience in which myxomas of the breast and nerves have pursued a malignant course—a course precisely similar to that pursued by sarcoma of the breast and nerves, respectively.

Treatment.—The appropriate treatment of myxoma is, in most instances, removal of the tumor; and, since the tumor is usually of small or moderate size, and is not deeply or dangerously situated, the operation may be practised without much danger. The method of treating mucous tumors in the uterus and the nose, will be described in the Articles devoted to the diseases of those organs.

Lymphoma or Lymphatic Tumor.

The lymphoma is a tumor composed of tissue resembling that of which lymphatic glands are formed. Great as are the difficulties by which the study of certain classes of tumors is encompassed, in no class are they more prominent than in that of the lymphomas; indeed, they are for the present insuperable, nor do I yet see how in the future they are satisfactorily to be overcome. The difficulty—nay, impossibility—of distinguishing between several different lymphatic glandular affections, either macroscopically or microscopically, and the close resemblance of the clinical characters of two or more diseases, which are probably widely different in nature, are causes of confusion from which there appears no sure escape. Even simple hypertrophies and chronic inflammatory conditions of lymphatic glands are often indistinguishable from true tumors, and surgeons are frequently confronted with the difficulty of deciding between a tubercular affection and lymphadenoma or simple hypertrophy.

It may, perhaps, facilitate the treatment of the subject, if one tolerably large group of lymphatic-tissue tumors is at once disposed of by considering all the primary heterologous formations of lymphatic tissue as round-celled sarcomas. The lymphatic-tissue tumors, for example, which occur primarily in bone, or in the breast, or in the testis, will be considered with the round-celled sarcomas—a manner of treating them which is justified by the close resemblance of their structure to that of the round-celled sarcomas, but still more by the similarity of the course pursued by the two diseases. They are usually described under the name of lympho-sarcoma—a term which will be referred to in the section on sarcoma. If this view be adopted, it will follow, as a consequence, that many of the primary affections of glands now described as malignant lymphoma, or lymphadenoma, must be regarded as round-celled sarcoma, the structure of which is slightly modified so that the disease resembles the tissue of a gland; a circumstance not difficult to account for when the influence of the parent-tissue on the structure of a tumor is remembered. Many of the lymphomas and lymphadenomas ought, therefore, to be considered in the section on sarcoma, but it will be more convenient to include a general description of them here, if only because the account will be sought for in this section.

A pure *lymphoma* might be imagined to be a tumor consisting of tissue precisely resembling that of a lymphatic gland, taking origin in adenoid tissue, encapsuled, and thus separate from the parent-tissue, increasing in bulk slowly but continuously, without pain or sign of inflammation, and presenting generally a rounded shape and well-defined contour.

But such a tumor does not appear to exist. The nearest approach to it is the general enlargement of a lymphatic gland, neither depending on tubercle, or syphilis, or inflammation, but rather hypertrophic in its character; affecting only one gland; slow in progress, but yet progressive; affecting the entire gland, but not tending to extend beyond the confines of the gland; not fixed to the surrounding structures; maintaining nearly the shape of the gland and its natural firmness; and presenting, on examination, the general and microscopic characters of the normal gland. Even this affection is very unusual, and, when every case of glandular enlargement depending on inflammation and tubercle has been rigidly excluded, is rendered so rare that one becomes almost doubtful of its very existence. Of the natural history of such cases no trustworthy account can be presented, for, since Schüppel has shown[1] that many of the enlargements formerly regarded as simple tumors or hypertrophies, are in truth tuberculous, the material from which the natural history should be drawn has been almost wholly withdrawn.

Instead of a single gland, it is much more usual to meet with enlargement of several neighboring glands; for instance, in the neck, or immediately beneath the lower jaw. Although all of the group may be enlarged, one of them is usually far larger than the others, and its size renders it so obtrusive that it often overshadows the enlargement of its fellows. Such a gland may attain the size of a walnut, or a racquet-ball, and may remain without any evidence of inflammation, indolent, movable, firm, smooth, painless, and occasionally slowly increasing in size, for as many as four, or six, or more years. I have seen more than one such case in children or young adults, and have thought that the disease was a hypertrophy, or true lymphatic tumor, and in this belief have removed the largest gland. It has shelled out with perfect ease, and on section has presented a homogeneous or granular surface, a yellowish color, but absolute freedom from fatty degeneration or caseation; indeed, all the characters which might be regarded as proper to a glandular tumor or hypertrophy. But microscopic examination has invariably discovered the presence of tubercles, usually very numerous and typical, with their central giant-cells, surrounded by epithelioid and lymphoid cells. It thus appears probable, if not, indeed, certain, that a tuberculous gland may remain almost unaltered in its essential qualities, without inflammation or perceptible degeneration, during many years. The affection of several neighboring glands is indicative of strumous disease rather than of simple tumor.

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[1] Untersuchungen ueber Lymphdrusen-Tuberculose. Tübingen, 1871.

Of pure or simple lymphoma, then, there is reason to doubt the frequent occurrence, and to wonder if the disease does ever occur, either affecting a single gland or several neighboring glands.

The term *lymphadenoma*, or *Hodgkin's disease*, has been given to an enlargement of several or many glands, certainly not tuberculous or simply inflammatory, and as certainly not merely hypertrophic, for the disease is malignant and often pursues a rapidly fatal course. It commences most frequently in the glands of the neck, affecting at first a single gland, or a group of glands. The growth usually proceeds quickly, and while the disease spreads to other glands, those first affected become exceedingly enlarged, and, losing their separate mobility and separate shape, are often moulded into a large, irregular mass of tumor. The glands on both sides of the neck are by and by diseased, and other groups of glands, those of the axilla, groins, chest, and abdomen, may become affected. But the disease is not necessarily limited to the lymphatic glands. The moulding of several glands into a single, solid mass is accomplished by the spreading of lymphatic tissue beyond and between the individual glands. Growths of similar lymphatic tissue occur in the spleen, liver, kidneys, skin, subcutaneous tissue, and walls of the intestines. And presently, usually within a few months or a year or two, the patient dies, borne down by the pressure of accumulated disease. Lymphadenoma may occur at almost any age, but it is most common in young adults. Those affected by it are often apparently of strong constitution and in admirable health; and this, with the adult age of the patient, helps to distinguish the disease in its early period from strumous disease. In its more advanced stages the diagnosis is not very difficult. The number of affected glands, the affection of widely distant glands and the absence of an adequate cause for their affection, the steady progress of the disease, and the absence of signs of inflammation, are characters proper to lymphadenoma, not to struma. Occasionally, suppuration is observed around rapidly increasing glands, and in rare instances large masses of such glands have sloughed completely out, leaving a cavity into which a closed fist could almost have been thrust. With the gradual progress of the disease, the health declines, and an increased number of colorless corpuscles usually appear in the blood ; often as many as from six to ten, or more, in a single field of the microscope.

Virchow has described as Hodgkin's disease what he calls "simple hyperplasia of the lymph-glands.[1]" This disease he separates from lympho-sarcoma, and lympho-sarcoma again from sarcoma of the lymphatic glands. His account of "simple hyperplasia" is very short, but there can be no question that he has included among the simple hyperplasias, cases of tuberculous glands, even if, indeed, his description of the disease is not entirely founded on the observation of very chronic tuberculosis of the glands. For, in the minute structure of the hyperplastic glands, he mentions the occurrence of giant and epithelial cells ; and, in their general characters, speaks of the granular appearance of the section, and of rounded or elongated bodies scattered through the tumors. The glands of lymphadenoma, examined after removal, present a yellowish or brownish-yellow color and a homogeneous section. But they differ in appearance according as they belong to the hard or soft variety. The hard are usually yellow or yellowish-brown in color, and more fibrous in appearance ; the soft are often white, and even brain-like. As the general appearance of the hard glands is fibrous, so is their minute structure very fibrous. All the constituents of the gland are increased in quantity; the follicular ends and cords are enlarged, and the number of their cells is greater; the lymph-paths can still be easily traced; but the capsule and the fibrous trabeculæ are so much thickened that the fibrous constituent of the tumor produces a decided effect upon its character. Although these glands do not convey the impression of being very vascular, they are much more vascular than the normal glands. The soft glands are characterized by the great increase in their cellular elements. The relations of the component parts of the gland are not so carefully maintained; the cells and the fine meshwork of the follicular portions are vastly increased in quantity, and, with the increase in quantity, there takes place also an alteration in the character of the cells, which are usually larger, less regular in shape, and less uniform than the normal lymph-corpuscles. Sometimes large cells resembling giant-cells are mingled with the other constituents.

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[1] Krankhaften Geschwülste, Bd. ii. S. 617.

Between the disease which has been just described and the disease which has been termed lympho-sarcoma, and which I regard as sarcoma of the lymphatic glands, I can at present find no clear distinction. And yet I believe that a distinction may exist, and that in this general description at least two separate diseases are included, closely allied perhaps, and nearly resembling each other, but possibly as distinct as typhus and typhoid fever have been proved to be. One of these diseases is unquestionably a sarcomatous disease; the other not improbably a simple tumor enlargement, affecting, not one alone, but several or many glands, or rather resembling in its nature the multiple lipomas or fibromas with which we are familiar.

This subject is rendered yet more complex by the fact that an enlargement of many glands occurs in association with certain constitutional conditions. In leukæmia, a great increase of size of many lymphatic glands, or of the spleen, or of both together, occurs with signs of fever, and a remarkable increase in the number of the colorless corpuscles of the blood. Here the lymphatic enlargement is regarded as subordinate in importance to the constitutional condition. But cases of leukæmia may and do occur in which the constitutional symptoms are not strongly marked, and the glandular affection is the most striking feature of the disease. And cases of lymphadenoma or sarcoma occasionally occur in which the enlargement of the glands is accompanied by fever, and by a much greater increase than usual in the number of the colorless corpuscles of the blood. So that the lymphadenomas or sarcomas must be distinguished, not only from strumous affections, but also from leukæmic and similar diseases. A. Winiwarter, in an article in Langenbeck's Archives,[1] terms the disease which has been here described under the name lymphadenoma, "malignant lymphoma," and separates it entirely from lympho-sarcoma. The latter term he employs only for round-celled or spindle-celled sarcomas which attack lymphatic glands, and which break out at one or more points in the interior of a gland, but are not at first diffused through its entire mass. But the clinical characters which Winiwarter attributes to malignant lymphoma are so ill-defined that it is evident to an impartial student of his paper that he has included among his cases several of strumous disease. And the distinction which he draws between lympho-sarcoma and malignant lymphoma, is not sufficient to establish a difference which can be justified. The difference is merely that which exists between certain anatomical varieties of sarcoma on the one hand, and between circumscribed and diffused malignant tumors on the other hand.

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[1] Archiv für klin. Chir., Band xviii. S. 98, 1875.

Treatment of Lymphoma.—The very uncertainty which prevails respecting the exact nature of a lymphatic enlargement, leads to a corresponding uncertainty in treatment. A disease which appears at the first sight to be almost trivial, may resist treatment of every kind; while a disease, extensive in the number and bulk of the affected glands, and most threatening in its aspect, occasionally yields unexpectedly to medicine, and undergoes complete and permanent resolution. The general rule should, therefore, be observed, with respect to all glandular affections, that no case is too trivial to deserve serious attention, and that no case is too grave to be despaired of. The treatment of strumous affections of the glands does not demand consideration here. Nor need attention be devoted to the treatment of the leukæmic affections, in which the constitutional condition plays so large a part. The treatment of the remaining diseases may be by medicine or operation. In the first place, the precaution should not be neglected of removing everything which may possibly be a source of irritation, and thus tend to protract or increase a glandular affection. Skin eruptions, decayed teeth, ulcers of the tongue, and similar causes of glandular enlargement, should be sought for in the neighborhood of the affected glands, and, if possible, should be removed early in the course of treatment; and where a lurking doubt exists of strumous taint, cod-liver oil and steel with other suitable remedies should be administered.

But where the disease exhibits characters pointing to a sarcoma, and is, indeed, a fair example of what has been described under the term lymphadenoma, in a stage not very advanced, no hope can be entertained of improvement from these remedies. In such cases arsenic has been recommended, and with justice, for the results of a carefully conducted course of arsenic are in some instances surprisingly successful. I have myself seen greatly enlarged glands, which I believed to be incurable—which had been steadily increasing in size during many months, or even a year—subside in the course of a few weeks under arsenical treatment. One young man, whose upper cervical and submaxillary glands formed a mass as large as his two fists, and who had been under treatment with iron, cod-liver oil, iodide of potassium, and other drugs, for a period of upwards of a year, with the only result that the glandular disease extended and continued to increase in bulk, rapidly improved on arsenic, and in two months was dismissed as cured. The preparation which is employed is almost always the liquor arsenicalis, in doses at first of from 5 to 8 minims, three times daily, after meals. Every week the quantity of the arsenic solution is increased by one minim, until symptoms of slight poisoning are produced—dryness of the fauces, suffusion of the eyes, pains in the epigastrium, and slight tremulousness. The quantity of arsenic which will produce these symptoms varies in different individuals, but in most instances from 13 to 15 minims of the preparation named may be given three times daily before actual discomfort is experienced. The disease seldom begins to yield until the larger doses have been reached, but the subsidence of the swelling is then sometimes very rapid. Injection of the tumors with liquor arsenicalis has also been practised, but the success claimed for it is scarcely sufficient to induce one to employ it, while an unfortunate chance, or slight want of caution, might be attended with very untoward results. Only one or two minims are thrown in, and the injection is repeated at intervals of two or three days. Violent inflammation or sloughing may be occasioned, or the tumor which is injected may grow much more rapidly than before. I have never been tempted to use arsenical injections, but have administered injections of perchloride of iron and of tincture of iodine. In one instance in which the latter was employed, a large mass of glands rapidly increased in size, and in a few days sloughed out, leaving a deep cavity in the neck, which never healed, for the patient—a young man, and previously apparently rather robust than delicate—died within a few weeks of this unfortunate occurrence.

Glands may be removed with advantage when they are very indolent, not very large, and not matted together, and when the enlargement has existed for many months or years. In such cases, although simple hypertrophy may be suspected, tubercle will almost invariably be discovered. Again, the question of removal of lymphatic tumors may be raised in the case of disease, apparently sarcomatous, which has resisted treatment by internal remedies. Large masses of glands have been removed, more particularly from the cervical region, in cases of this description; but the result has not been happy, for in most, if not all, instances the disease has recurred with great rapidity, and no material benefit has been attributable to the operation. The removal of glands which are undoubtedly sarcomatous cannot therefore be recommended. The extension from gland to gland is so rapid, and the disease so speedily affects a wide-spread group of glands, that the operation appears useless.

Myoma or Muscular Tumor.

The myoma is a tumor consisting either of striped or unstriped muscle. The former variety is the *rhabdomyoma*, the latter is the *leiomyoma*.

The myomas which are composed of striped muscular tissue are exceedingly rare. They occur in the heart, the tongue, the kidney, the testis, and the muscles, especially of the lumbar region. Pure *rhabdomyomas* probably are always of congenital origin; and even tumors which contain striated-muscle fibres, unless the fibres have been entangled in the growth of the fatty, fibrous, or sarcomatous tissues, in the midst of which they lie, are much more often congenital than the product of extra-uterine life. Indeed, the possibility of the new formation of striated fibres in the human subject after birth has been questioned. The undoubtedly congenital tumors which contain striated muscle are, for the most part, large mixed tumors, composed of various formed and embryonic connective tissues—fibrous, cartilaginous, sarcomatous, etc.

Myomas composed of unstriped muscle (*leiomyomas*) are not uncommon in certain situations—the uterus and prostate; they occur also in the appendages of the uterus, in the walls of the œsophagus, the stomach, and intestines, and in the cutis vera of the skin, but only rarely in the last-named situation. They constitute many, probably most, of the "fibroids" of the uterus and of the chronic enlargements of the prostate.

Characters and Course of Myomata.—Unstriped myoma appears to be exclusively a disease of adult age, and occurs so much more frequently in persons beyond the middle period of life, that old age may be regarded as an important predisposing cause of its occurrence. For example, chronic enlargements of the prostate are almost limited to persons over 55 years old; and fibroid tumors of the uterus, although they occur in women at a much younger age than this, are very rare before the middle period of life. The chronic catarrh of the mucous membrane covering the affected parts, to which Virchow is disposed to attribute the formation of myoma, is not so frequently observed in connection with the enlargement of the prostate as to lend color to the theory.

Myomas grow either as continuous or as discontinuous tumors. Most of the enlargements of the prostate consist in a general hypertrophy of the organ, and the two lateral lobes are for the most part symmetrical in size and appearance. In some instances the middle lobe becomes enlarged out of proportion to the general hypertrophy, and projects at the orifice of the urethra so as to obstruct or even completely prevent the passage of urine. Distinct spherical or spheroidal tumors may, however, occur in the prostate, and many of the conditions which look like general hypertrophies or continuous outgrowths prove on examination to contain circumscribed tumors. The entire uterus may be enlarged in like manner with the prostate, but the rule is inverse for the two organs, for discontinuous or distinct tumors are proportionally much more numerous than general enlargements of the uterus. Many of the tumors of the uterus project into the interior of the organ in the form of polypi, large, fleshy, and with thick stalks. Others lie in the substance of the uterine wall, as circumscribed, spherical, or spheroidal tumors, encapsuled, and perfectly separate from the tissues of the womb. A third set project on the outer surface of the uterus beneath the peritoneum, where they sometimes form tumors of considerable bulk; these, too, may assume the form of polypi. The uterus may be the seat of multiple tumors, and even where only one tumor exists, there is often great hypertrophy of the uterine wall, not only in the immediate vicinity of the tumor, but throughout. The muscular tumors of the œsophagus and stomach, and those of the intestines, project on the outer, or more frequently the inner, aspect of the wall of the tube, and sometimes, in the œsophagus especially, form large polypoid growths.

Appearance after Removal.—The consistence of myomas varies from an almost scirrhous hardness to that of the softer fibrous (fibro-cellular) tumors. Those of the prostate are generally firm, and sometimes hard; but those of the uterus may be either firm or soft. On section, the general aspect of the typical muscular tumors so closely resembles that of the most typical fibrous tumors, that the difference cannot be distinguished. Glistening bands of fibres, interlacing and anastomosing, comprise the greater portion of the growth in either case. The vascularity of the firmer sorts is not great; from a study of injected specimens it would appear almost null, for, while the wall of the uterus around the tumor is deeply reddened, the tumors are scarcely stained with the injection.

Microscopic Appearances.—The muscle-cells of muscular tumors resemble those of the organs in which they grow, but are often larger. (Plate XVIII. Fig. 6.) They are arranged in bands or trabeculæ, which usually present a wavy aspect; but the appearance is widely different from that of wavy fibrous tissue. Even if it were impossible to distinguish the muscle-cells and elongated nuclei, the general aspect of the trabeculæ is so coarse, and the waves are so angular, that the two tissues could not be confounded. Mingled with the muscle-fibres are round and oval cells, and even the purest myomas contain a small proportion of fibrous tissue. Most myomas, indeed, contain a large alloy of fibrous tissue.

Metamorphoses and Combinations.—Whether as the result of the admixture with fibrous tissue, or owing to the special liability of muscular tissue under certain conditions to calcify, these tumors occasionally undergo partial or complete calcareous metamorphosis. The change seems almost limited to the tumors of the uterus. That it is connected with the age and certain conditions of the growth, is probable, far more probable than that it depends on the patient's age, for tumors of the prostate, even in the oldest men, rarely calcify. Ossification of a muscular tumor has been described. Cystoid cavities are formed by a process of softening of the tissue of the tumor in some of the softer varieties of muscular tumor, and the largest specimens of uterine fibroid may contain numerous and large cavities formed in this manner.

The constant combination with fibrous tissue has been already mentioned. It is by far the most frequent of the combinations of muscle-tissue, but it is not the only one. In the prostate, gland-tissue frequently forms a part of the tumors, and in very varying proportions; for while some tumors are formed almost entirely of muscle, and contain very few gland-follicles, other tumors consist largely of gland-follicles with a very small proportion of muscle. Although most of the myomas are not plentifully supplied with vessels, some of them are so vascular that they have been regarded as combination-tumors of muscle and vessel.

Symptoms of Myomata.—In spite of the small supply of vessels which most myomas possess, they are frequently associated with severe and frequent hemorrhage. But the blood appears almost always to be poured out from the vessels of the mucous membrane of the affected organ. It can scarcely be maintained that the hemorrhage depends on the nature of the tumor, for the symptom is well-nigh limited to the myomas of the uterus, those of the prostate seldom even bleeding slightly unless they have been injured. The difference is so remarkable that hemorrhage is reckoned an important symptom of fibroid tumors of the uterus; the absence of hemorrhage just as important a symptom of enlargement of the prostate.

Myomas are liable to ulceration, but the ulceration is more often of the mucous membrane covering them than of the substance of the tumor. The peritoneum is also liable to inflammation in the case of subperitoneal growths. Myomas occasionally slough, and are completely cast out, when a spontaneous cure of the disease may result. Myomas are, too, some of the very few tumors which undergo partial or complete resorption. Complete disappearance of a myoma is probably of very rare occurrence. Where shrinking has taken place to such a degree that the tumor has seemed entirely to disappear, it has been found, when the opportunity for examination has been given after death, that there has still remained a tumor, but of unimportant size. The shrinking may be due to cicatrization of inflammatory products, when the tumor becomes as hard as a scirrhous growth; or it may probably be due to fatty degeneration of the muscular fibres, similar to that which occurs in the natural involution of the uterus. That it should be noticed chiefly or solely in tumors of the uterus, and should take place most frequently after the complete cessation of the menses, might almost be foretold from what is known of the natural changes which the uterus exhibits after pregnancy and after the change of life. Fortunately, with the diminution of the tumor the alarming symptoms of which it has been the cause frequently disappear, and the disease is practically cured.

Diagnosis and Treatment.—The clinical characters of myomas can scarcely be considered here. External myomas are so rare, and so unimportant when they do occur, that an elaborate description of their characters would not be necessary even if it were possible. The symptoms of the muscular tumors of the uterus and prostate will be fully described in the articles on diseases of those organs. The diagnosis and treatment of the disease also falls more appropriately to the duty of writers on those subjects. It may, however, be said here that it is impossible to diagnose between a myoma and a fibroma, and this might be expected from what has been stated of the close relation and resemblance of the two diseases. It may also be said that a myoma is a perfectly benign tumor, and that the dangers associated with its presence depend, not on the structure of the tumor, but on the importance of the parts which it attacks.

NEUROMA OR NERVE-TUMOR.

This is a tumor consisting of nervous tissue, either ganglionic or fibrous. Here it is necessary to point out a distinction which must be clearly understood and borne in mind through the whole consideration of this subject. A neuroma is not merely a tumor of a nerve, or a tumor of the brain or spinal cord, but is essentially a tumor of nervous tissue. It would scarcely be necessary to draw attention to this distinction, were it not that the term neuroma has been misapplied to tumors occurring in the course of nerves, and especially to fibromas of nerves, so that many persons, hearing it employed, accept it in that, rather than in its true, sense.

The tumors which are composed of ganglionic tissue have been termed medullary, a bad term, because, although it may be correctly applied in the present instance, it has been used in other senses when applied to tumors. The term ganglionic is for this reason alone to be preferred. The tumors which are composed of nerve-fibres may be either medullated (myelinic), or non-medullated (amyelinic), according as they contain medullated or non-medullated fibres.

True neuromas may grow in connection with any of the nerves, but are much more frequent upon the spinal than the cerebral or sympathetic. The ganglionic tumors occur in the brain, or, more properly, upon the brain, for they form small tumors in connection with the cortex. Nerve-tumors may, too, be heterologous. They have been found in the testes and ovaries, and in the sacral region. These tumors are not usually pure nerve-tumors, but mixed growths, consisting of several different tissues, among which nervous tissue forms one, but generally not the most important.

A large number of the nerve-tumors are probably congenital, those of the nervous centres especially. The nerve-fibre tumors may occur at any age, but many of them are also probably congenital.

Neuromas, of whatever kind, grow slowly, and, as a rule, do not attain a large size. The ganglionic tumors are usually very small, but the nerve-fibre tumors sometimes reach the size of a tennis ball, or even a larger size than this.

APPEARANCES AFTER REMOVAL.—The general characters of the nerve-fibre tumors are so like those of fibrous tumors, or of fibro-myomas, that it is impossible with the naked eye to make the diagnosis between them. They are usually very firm or hard, and inclosed in a fibrous capsule, and they present on section various arrangements of bands of fibres such as are common in fibromas.

It is almost as difficult to make the diagnosis of a non-medullated nerve-tumor from the *microscopical examination*, for the very fine fibres, closely interwoven, very nearly resemble the tissue of some of the fibrous tumors. The difference may be recognized by coloring sections with gold, but this method is not usually adopted unless the presence of nervous tissue is suspected, or is especially sought for. Sections examined fresh, or colored with hæmatoxylin, present no distinctive characters. Even the medullated tumors may be overlooked unless the examination be very thorough. The coloring of the axis-cylinders, and absence of color in the medullary sheaths, however, is the feature by which the distinction may be made. The frequency with which nerve-tissue is mingled with other tissues, and the abundance of these tissues, make the diagnosis of neuroma still more difficult. Fibrous and sarcomatous tissue are largely represented in these compound tumors, and pure nerve-tumors are much more rare than compound growths. The sarcoma-tissue is usually spindle-celled, and the spindle-cells are often so fine and slender that they may well be mistaken for embryonic nervous tissue, and thus the suggestion of Billroth may be justified, that sarcoma should include not only embryonic connective tissue, but also embryonic nerve (and muscle). The ganglionic tumors, like the fibre-tumors, are generally mixed growths, and, in addition to nerve-fibres, contain fibrous or other tissues mingled with the ganglion-cells and neuroglia which form their essential structure. The cells are round, oval, or stellate, are often of large size, and resemble the normal nerve-cells.

METAMORPHOSES AND COMBINATIONS.—Of the metamorphoses and diseases of nerve-tumors we are not in a position to speak. The combinations have been more than once alluded to. Fibrous tissue is of almost invariable occurrence; sarcoma-tissue is a frequent combination; mucous tissue is by no means infrequent. The second, and perhaps the third of these tissues may, perhaps, be regarded as young nerve-tissue, and so the tumor may be looked on as an embryonic tumor which is partly organized.

SYMPTOMS AND DIAGNOSIS.—The clinical characters of neuroma resemble those of fibroma and sarcoma so closely that it appears at first impossible to distinguish between them. The diagnosis of neuroma from fibroma is, however, unimportant, for the neuroma, like the fibroma, is a perfectly benign tumor.

TREATMENT.—The neuromas which grow upon nerves may be removed, like fibromas in similar situations, without, in most instances, serious damage to the nerve. The tumor is generally encapsuled, and may easily be freed from its attachments to the nerve. A longitudinal incision through the epineurium, and a few touches with the knife, always in a longitudinal direction, suffice for its speedy and complete removal. Where the tumor is more intimately blended with the nerve, it is sometimes necessary to remove a portion of the latter, after which an attempt should be made to fasten the divided ends together, and thus maintain the continuity of the nerve.

The neuromas of the brain are beyond the reach of treatment. The compound growths in which nerve-tissue is more or less largely represented, require no other treatment than that which is dictated by the general principles which guide the treatment of the tumors of the affected part.

It is to be noted that pain does not, contrary to what might have been expected, constitute an important symptom of neuroma. It was at one time naturally imagined that the painful subcutaneous tumors would prove to be, at least in part, nervous. But this expectation has not been fulfilled, for these tumors usually do not contain nerve-tissue; and, moreover, cannot in many instances be demonstrated to bear a close connection to a nerve. The bulbous tumors which form about the ends of nerves in stumps, certainly are extremely sensitive. But these tumors, although they often contain a fair proportion of nervous tissue, are chiefly composed of fibrous tissue. They can scarcely therefore be regarded as true neuromas.

ANGEIOMA OR VASCULAR TUMOR.

The angeioma is a tumor composed chiefly of vessels, or of spaces into which vessels freely open. These tumors are recognized under the common name of *nævi*, and although the term angeioma has been applied to them for many years past, they are so much more commonly called nævi that the other name has never become popular among surgeons.

Vascular tumors offer several different varieties. They may be arterial, venous, capillary, or what is called cavernous, where numerous freely anastomosing cavities take the place of capillaries or small veins. They may, too, be lymphatic, and again may be cavernous, or composed of dilated lymphatic vessels. It will be convenient, for purposes of description, to consider, first, the arterial angeiomas, then the other forms of blood angeioma, and lastly, those which are connected with lymphatic vessels.

ARTERIAL ANGEIOMAS, or, as they are often called, *arterial nævi*, *aneurisms by anastomosis*, or *cirsoid aneurisms*, may appear in one of two different forms, either as a dilatation and lengthening of the arteries of a certain area or region (*aneurism by anastomosis*), in which case there may be a formation of new vessels, or as a dilatation and lengthening of an arterial stem and its branches (*cirsoid aneurism*). Both these conditions affect chiefly the arteries of the scalp, the temporal and occipital, but occur also more rarely in connection with other vessels, the posterior auricular and supra-orbital, and the vessels of the upper lip. They may be congenital, but are often of extra-uterine formation, and may even appear late in adult life. In some instances the disease can be clearly traced to injury, but in other cases it appears to form spontaneously. Examination of these arterial nævi shows that the disease in the most typical cases is limited to the arteries, and does not materially affect the veins and capillaries, or entail an increase in the surrounding connective tissues. Indeed, these tissues more often undergo atrophy than hypertrophy from the increasing pressure of the vessels, which not only become greatly dilated and hypertrophied, but are at the same time coiled and twisted, and interlaced with one another so as to appear like a group of coiled worms. In some cases the vessels lose their uniform calibre, and undergo irregular dilatation, becoming varicose and sacculated. The structure of their coats is not materially altered. Not only are the arteries of the tumor widely dilated, but the arteries which supply it are often greatly enlarged, so that their calibre is in some instances increased twofold. The supply of blood to arterial nævi of the first form is not derived from a single source, but often enters the tumor from vessels which communicate with it on every side. Some of these dilated vessels, and the enlarging tumor itself, channel or hollow the bone on which they lie.

Diagnosis.—Arterial nævi are, for the most part, exceedingly easy to recognize. In the larger tumors the form and convolution of the vessels may be easily made out through the skin which covers them, and this alone is usually so striking a feature as to stamp the disease. But all these tumors, even the smallest and in other respects the least typical of them, pulsate with regularity and often with considerable force. The pulsation cannot, as a rule, be controlled by pressure on a single artery in the near neighborhood of the disease, and in some instances cannot be controlled by pressure upon either distant or surrounding vessels, however carefully it may be applied.

Treatment.—Under these circumstances, it will be understood that the disease is often difficult, and may be most formidable, to deal with. Even the smallest tumors bleed profusely during their removal, and I have seen excessive hemorrhage from such a tumor situated immediately above the orbit, and measuring only an inch by half an inch. It was necessary to tie six or eight arteries before the hemorrhage was arrested. In some cases arterial angeiomas may remain without special treatment during years, without detriment to the patient's health, for some of them neither increase quickly nor give rise to much discomfort. But, more frequently, they increase in size, and cause discomfort by producing noises in the ear of the affected side, or worse than discomfort by ulcerating and bleeding, sometimes profusely. Such tumors must usually be dealt with by operation; for pressure, even when it has been employed with extreme care, has seldom availed much. The main artery—in most instances the common carotid—may be ligatured; but, for the reasons which have been already stated, this course can seldom be relied on. The tumor may still continue to increase in size, and hemorrhage may be as severe as before the operation. The means which offer the best prospect of success are destruction of the tumor by the galvano-cautery, and complete removal. For the former, the cautery wire may be passed beneath the growth, heated, and made to cut completely through it. This proceeding is repeated until the tumor has been destroyed piece by piece. The heated wire greatly reduces the danger of hemorrhage, but does not entirely avert it. Even if there be no bleeding at the time of the operation, hemorrhage may occur with the separation of the sloughs. The alternative operation of complete removal is certainly the surest means of cure, but it is fraught with the gravest danger when the tumor is of large size. The supplying vessels should first be ligatured through an incision immediately around the growth, each vessel being separately taken up as it is cut through. When all these vessels have been tied, the tumor should be rapidly removed, and the vessels which enter its under surface as quickly as possible secured. The operation may be rendered less difficult and dangerous by the application of compression, during its performance, on the main artery of the affected part, and by the employment of the clamp-forceps which are used for the temporary arrest of hemorrhage during ovariotomy and similar operations.

NON-ARTERIAL ANGEIOMATA.—The *non-arterial* varieties of angeioma are much more frequent than the arterial. They are indeed so numerous that a week never passes in the out-patient practice of a large hospital without producing at least one case. The *venous* and *capillary* nævi are more frequently met with than the *cavernous*, not merely because they are more numerous, but because the cavernous tumors more frequently attack the liver, and such deep structures as the muscles, while the vessel-nævi more frequently affect the skin and subcutaneous tissue.

Characters and Course of Venous and Capillary Nævi.—All parts of the surface of the body are subject to the occurrence of venous and capillary nævi, but the head and face,[1] and the trunk, are more often affected than the extremities. They grow in the most unfortunate situations, the tip of the nose, the eyelids, the lips and cheeks, and the ears. They are very frequent on the hairy scalp, and about the neck and back. But their occurrence is not limited to the skin and subcutaneous tissue. They grow in and beneath the mucous surface of the lips and cheeks, the tongue, and the gums, and more rarely in the muscles, the bones, and even in the brain. They are almost invariably congenital, or growths of early infancy; for, when the history is not clearly one of congenital occurrence, it is that the tumor was first noticed shortly after the birth of the child, as a minute speck or dot. Whether it be congenital or of infantile origin, the speck or dot may remain stationary, or may increase in extent and bulk, or may take a third course and diminish in size, and gradually disappear. Most nævi increase in size, and of those that are cutaneous, the manner of growth may sometimes easily be observed. The red patch or area which constitutes the disease increases at its margins by putting forth vessel-loops and *culs-de-sac*. But more frequently the disease, watched thus, appears to spread by punctiform dots scattered in close proximity to the tumor, but apparently unconnected with it until the intervening space becomes filled, or is bridged over, by lines of vessels.

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[1] [See Plate XVI., Vol. III. page 368.]

Anatomical Appearances.—The venous and capillary, like the arterial nævi, consist of dilated, coiled, and twisted vessels, many of which pursue a corkscrew course. They rarely maintain a uniform calibre, but become varicose and sacculated. Their walls are usually thickened, but no new elements are introduced into them. The growth of new vessels may probably be by any one of the different methods by which new vessels are formed physiologically and pathologically. Two methods have particularly been described: one, the formation of loops by granulation buds, which grow out from the walls of the previously existing vessels; the other, by the channeling of the bodies and processes of anastomosing branched cells. The formation of granulation-tissue in large quantity has been observed in the immediate vicinity of some growing angeiomas.

The *microscopic characters* of venous and capillary angeiomas are such as the macroscopic appearances would lead us to expect. The course, even of capillaries, cannot be followed far, but the twisted and corkscrew course can often be discerned, and the irregular dilatation and sacculation is very evident. The thickening of the vessel-coats, which is almost constant, is also very plain. In addition to the thickening of the vessel-coats, an intervascular material is always present, generally a wavy fibrous tissue, nucleated but not richly so. The constancy of this or some other connective tissue in venous and capillary nævi, and in the cavernous tumors, and the abundance in which it is present in some tumors, has led certain surgeons, among whom Birkett may especially be mentioned, to conclude that all these tumors ought rather to be regarded as highly vascular, fibrous or connective-tissue growths, whose solid structure is their essential feature, and whose vascularity is, so to speak, an accident. Unquestionably there are grounds for the acceptance of this theory, but there are stronger grounds for its rejection. The diseased vessels are not only the most striking feature of these nævi, but, in every respect, their most important element. They form much more than the moiety of the tumor, and the extension of the disease is always by new vessels. If it recur after removal or destruction, the recurrence is invariably in the form of vessels. From the beginning to the end of its career the connective tissue of the tumor holds a subordinate position, and appears to exercise no influence on its course.

Metamorphoses, etc.—The *decrease and disappearance* of venous and capillary nævi have been mentioned. The manner of their occurrence is not thoroughly understood. It is not improbable that thrombosis of the supplying vessels is an early and essential element in the cure. Either as a part of this process, or of separate occurrence, are what are called the fibrous and fatty degenerations of nævi. Instead of merely shrinking and slowly disappearing, the nævi remain as solid masses, much smaller than the original tumors, and apparently not more vascular than an ordinary fibrous or fatty tumor. The vessels, however, have not been obliterated, for when these masses are examined years after this transformation has occurred, numerous vessels filled with blood clot may often be discerned. The combinations of vascular with other tissues are very numerous, but probably many of them are only examples of excessive vascularity of other tumors. Fibromas, sarcomas, myxomas, myomas, lipomas, are all liable to be thus hyper-vascular.

Nævi are very subject to inflammation and ulceration. The central portions of the growth are usually affected. The ulceration in some instances penetrates deeply into the substance of the tumor, but in other instances remains quite superficial. In either case it is often the cause of severe hemorrhage. Rarely, sloughing occurs. From one or other of these causes the disease may be spontaneously cured; for the tumor may be completely destroyed by gangrene or ulceration, and inflammation alone may suffice to induce thrombosis of the vessels with subsequent shrinking of the tissues.

Cavernous Nævi.—Before discussing the clinical characters, diagnosis, and treatment of the venous and capillary angeiomas, it will be well to describe the *cavernous* nævi, the exact position of which is not quite clear, and to point out the anatomical differences which have caused them to be considered, especially by the German pathologists, apart from the venous and capillary tumors. They contain a large number of cavities, sometimes very small, sometimes as large as cherry-stones.[1] Between these cavities there is such free communication that an injected fluid thrown into one passes instantly into the others. They are lined with endothelium, and are separated by a variable quantity of intervening tissue, the structure of which is chiefly white fibrous tissue, intimately mingled with yellow elastic tissue, and containing almost invariably organic muscular fibres. When the tumor is removed, blood runs out from all the spaces, and the mass shrinks to less than half its former volume, presenting the appearance of a mesh-work, the fibres and partitions of which are white and tough. The characters of the tissue are those of the erectile tissues, that of the penis for example. Occasionally phlebolites are noticed in the cavities. Arteries, sometimes of normal calibre, sometimes dilated, open into the cavities, and veins convey the blood directly away from them. They therefore appear to occupy the position, in the circulation, of the capillaries, or of the capillaries and smallest veins. The larger and older tumors are usually inclosed in a fibrous capsule, a rare condition in venous and capillary angeiomas; through the capsule the vessels pass into and out of the tumor. The development of the cavernous angeiomas is probably by the development and dilatation of vessels which become sacculated, and which, by pressure, produce absorption of the surrounding textures. Their walls thus come immediately in contact, and, by the continuation of the pressure, are absorbed at certain points, so that the vessels or vascular channels communicate through many openings. Their original tubular nature is by this means destroyed and replaced by the system of anastomosing cavities which forms the essential feature of the cavernous angeiomas.

The separation of these tumors from the venous and capillary nævi has not been generally adopted by English and American surgeons, nor does there appear, if the history of their development be correct, a sufficient reason for the separation. They occur, like the other non-arterial nævi, in the subcutaneous tissue, the muscles, and the tongue; but their seat of election is the liver, where they commonly form growths as large as an English walnut. The tumors of the head and face have a special predilection for the region of the fœtal fissures—about the ear, the lips, and orbit; this tendency is so marked that these tumors have been termed *fissural angeiomas.* Other organs are liable to be attacked besides the liver—the kidneys, spleen, and uterus. The vascular tumors of the internal organs, though they sometimes attain a large size, seldom or never produce any disastrous effects. Yet, from the liability of the superficial tumors to ulcerate and bleed, it might be expected that the superficial nævi of the organs would sometimes pursue a similar dangerous course. But, whether it be that they are far better protected from violence, or that the pressure of the surrounding organs is beneficial, these dangerous events appear to be exceedingly rare.

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[1] In one tumor which I saw many years ago, and of which there is a drawing at the Hospital for Sick Children, Great Ormond Street, London, some of the spaces were as large as a walnut. The patient was an infant only a few days old; the tumor was situated on the buttock.

Symptoms of Non-arterial Nævi.—The clinical characters of all non-arterial nævi are usually very decided, unless the tumors are very deeply seated. The cutaneous nævi appear as marks (mother's marks), or plaques, or moles, of red color. The redness is always sharply circumscribed; and, even when the growth is spreading, each dot, or loop, or line, is clearly defined; the color varies from the brightest scarlet to a dull-red or livid hue. Some nævi exhibit a uniform tint, but more commonly the coloring is unequal, and in many instances lines of vessels can be traced upon the surface; the surface, like the color, is liable to variation—it may be quite smooth and flat, or slightly rounded, or warty, like a papilloma. The disease may be very limited in extent, or may extend over half the head and face, producing the most serious disfigurement. The subcutaneous nævi form more definite tumors, often of round or oval shape, sometimes distinctly circumscribed, but in other instances ill-defined, and gradually shelving into the surrounding tissues; they feel soft and compressible, and are smooth, or only slightly lobed; the skin over them is seldom natural in color, but has a dull-blue or livid hue, very different from the color of the cutaneous growths, but very characteristic, nevertheless. Both the cutaneous and the subcutaneous nævi are compressible, and may be much lessened in bulk by a moment's continuous pressure. But a more characteristic property is the power which some of them possess of rapid or sudden enlargement, the property of erectility, on account of which they have been sometimes termed erectile tumors. Prolonged coughing or crying of the patient will often cause a nævus thus to swell; and it is stated that some of them will swell and become "erect" under the influence of irritation, like the physiological erectile tissues. But I think that the erectile power of these vascular tumors has been overrated, and that, as Paget has pointed out, they deserve the name erectile rather on account of the similarity of structure of many of them (the cavernous) to that of the erectile tissues, than because they imitate these tissues in erectile power.

Diagnosis.—The decided characters of the more superficial nævi render the diagnosis usually very easy; and when, to these characters, the fact of their origin before or during early infancy is added, it is almost impossible to mistake them. Occasionally, a slight difficulty arises in distinguishing between the true vascular tumors and other tumors which are hypervascular; but the more solid feel of most of these growths, their limitation in most instances to the deeper structures, and the fact that they are not, like the nævi, proper to early infancy, must be taken into account in the diagnosis. A deeply-situated nævus may be taken for a congenital cystic tumor, especially when it grows in the region subject to these tumors. I have lately seen such a growth, deep down in the back of the neck and shoulder of a baby. The diagnosis was made by observing that the integuments over it, although it lay at some depth beneath them, were faintly discolored.

Prognosis.—The prognosis of non-arterial nævi, as far as life is concerned, is favorable; indeed, the largest and most formidable of them rarely prove fatal. But they are often very difficult to cure, and disfigurement may result from their most successful treatment. The extensive discolorations termed port-wine marks are scarcely improved by treatment; for the discoloration can only be substituted, in the most successful case, by an extensive scar, equally disfiguring. It may be laid down, as a general axiom, that the cure of a cutaneous nævus by almost every known method entails the production of a scar equal in extent to the area of the nævus. The recognition of this fact, and the knowledge that nævi sometimes shrink and disappear, lead many surgeons to adopt an expectant plan of treatment. The course of the disease is watched, and as long as there is no very rapid increase of the tumor, no active measures are employed. Unfortunately, this reposal of confidence in the good offices of nature is far too frequent and too long continued, and is apt to be met by a very ill return. The nævus continues slowly and steadily to increase in size; and what was a mere speck in an infant a few days after birth, becomes a plaque the size of a sixpence or a dime by the time the child is six months old. A tiny drop of nitric acid would, in the first instance, have sufficed for the complete cure, and the scar would have been scarcely appreciable. But now the cure is far more difficult, and the scar will be six times as large.[1]

Treatment.—If a nævus is increasing in size, it should be treated; nay, the safer rule for guidance is, if a nævus is not diminishing in size, it should be treated.

The selection of an appropriate method of treatment depends, to a certain extent, on the character and situation of the tumor, but is apt to be embarrassed by the number and variety of methods from which the selection may be made. The various methods may, however, I believe, be classed under three heads: those which aim at inducing shrinking of the tumor; those which bring about its complete destruction; those by which it is at once removed. The means of the first class most commonly employed are pressure, the application of collodion, and galvanism. The two former are rarely successful, but the last named has of late been highly spoken of. Pressure may be produced merely by pads and strapping, but the difficulty of maintaining equable and constant pressure, sufficiently firm to be of use and yet not hard enough to produce ulceration or sloughing, is probably one great reason why it is not more often employed. The application of collodion is of course easily made, and the collodion is easily removed; but, although under its use the vessels are constricted, and the tumor loses much of its color, the good result is for the most part only temporary.

Galvanism is employed in the form of the continuous current, with the object of producing, not ulceration or destruction of the tumor, but clotting, with decomposition of the blood and perhaps of certain of the tissues, followed by shrinking of the mass. Any good constant-current battery may be employed. A variable number of cells is required, according to the size of the nævus, but an average number of six or eight,[2] if the battery is in good working order. Insulated needles made of gold are the best for the purpose: for a small nævus, one or two needles at the negative, and a charcoal point at the positive pole. The needles are thrust well into the tumor, so that the insulated portions are in contact with the integument; otherwise small sloughs are formed around each puncture. The operation lasts for several (ten or fifteen) minutes. Shortly after the introduction of the needles, bubbles of gas pass out beside them, and similar bubbles may be seen traversing the superficial vessels. The nævus then becomes firm from the formation of a clot, and changes its color to a bluish-white. The operation is painful, so that an anæsthetic is usually administered, but there is no subsequent pain. From one to three or four sittings are required, according to the size and character of the nævus, and the sittings are usually conducted at intervals of a week or longer. The foregoing directions are, for the most part, those given by Knott.[1] He claims to have thus treated a large number of nævi, varying in size, in situation, and in character, and always with a good result. The action of the battery is very certain, and only a faint cicatrix remains. I cannot say that my own experience and observation have led me to a similar conclusion. Even where the effects described have been produced, they have been very transitory, and success has not been nearly uniform. I am unwilling, however, to judge too hastily a method which is highly spoken of by several competent surgeons, and therefore at the present time am engaged in carrying out a fresh investigation of it.[2]

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[1] I have known a medical man in large practice bring his own child more than a hundred miles to London, for the treatment of a cutaneous nævus of the face, about two-thirds of an inch in diameter, which he told me was a scarcely visible red point a week after the child was born. If, instead of watching it for several months, he had at that time touched it with the tiniest drop of nitric acid, the journey might have been avoided, and the nævus cured without appreciable scarring.

[2] As many as fifteen or even twenty-five cells are required when the weaker forms of battery are employed.

Another method by which thrombosis and shrinking of a nævus may sometimes be produced, is by the injection into it of very small quantities of the tincture of the perchloride of iron. About three minims of the pure tincture are injected by means of a screw syringe, and an equal quantity may be thrown into three or four different parts of a nævus the size of a walnut. The injection should be repeated in different parts of the tumor at intervals of three or four days, until the whole mass has been rendered solid. The objections to this method are that it is very uncertain; suppuration and sloughing are apt to be produced by too free use of the syringe; and it is not free from danger to life. More than one case is on record in which, apparently from embolism, sudden death has taken place during or immediately after the operation. It is most suitable for the treatment of nævi which can be completely surrounded by a ring or band, and thus separated for the time from the general circulation.

The methods by which destruction of the tumor may be effected are very numerous. Among the most important of them are vaccination; the application of nitric acid or ethylate of sodium; the introduction of nitrate of silver or caustic potassa; the passage of setons; ligature of the growth; and the use of the cautery. These methods do not all entail an absolute destruction of the tumor. Vaccination, for example, sets up inflammation in the nævus, and cures it by thrombosis and subsequent shrinking. It might, therefore, be placed in the preceding class of remedies. But it often causes ulceration and cicatrization, and, on this account, belongs more properly to this class. It is employed only for cutaneous nævi, and is, at best, a very uncertain remedy. The vaccination punctures are made immediately around the nævus, and, even when the treatment is successful, leave unsightly scars. Nitric acid is very frequently employed for the destruction of cutaneous nævi. The strongest yellow fuming acid is used, and is applied with a glass rod, or, better still, a piece of stick, the surrounding parts having previously been protected by oiling them, and care being taken to soak up with blotting-paper any acid which runs beyond the nævus. In a few days the nævus sloughs out, and a sore remains which requires simple treatment. The ethylate of sodium is applied in the same manner as nitric acid. It acts, according to Dr. Richardson, as a nascent caustic. A thick black scab forms on the surface of the nævus, and as soon as this separates, usually within a week, a second application of the fluid is required. Several applications are usually needed. This method is said to be applicable to nævi of almost every kind and size. I have found it exceedingly useful for cutaneous nævi, quite useless for the subcutaneous and larger growths. It results in the formation of rather a thinner scar than that produced by nitric acid.

The introduction of nitrate of silver into nævi is used for the mixed or

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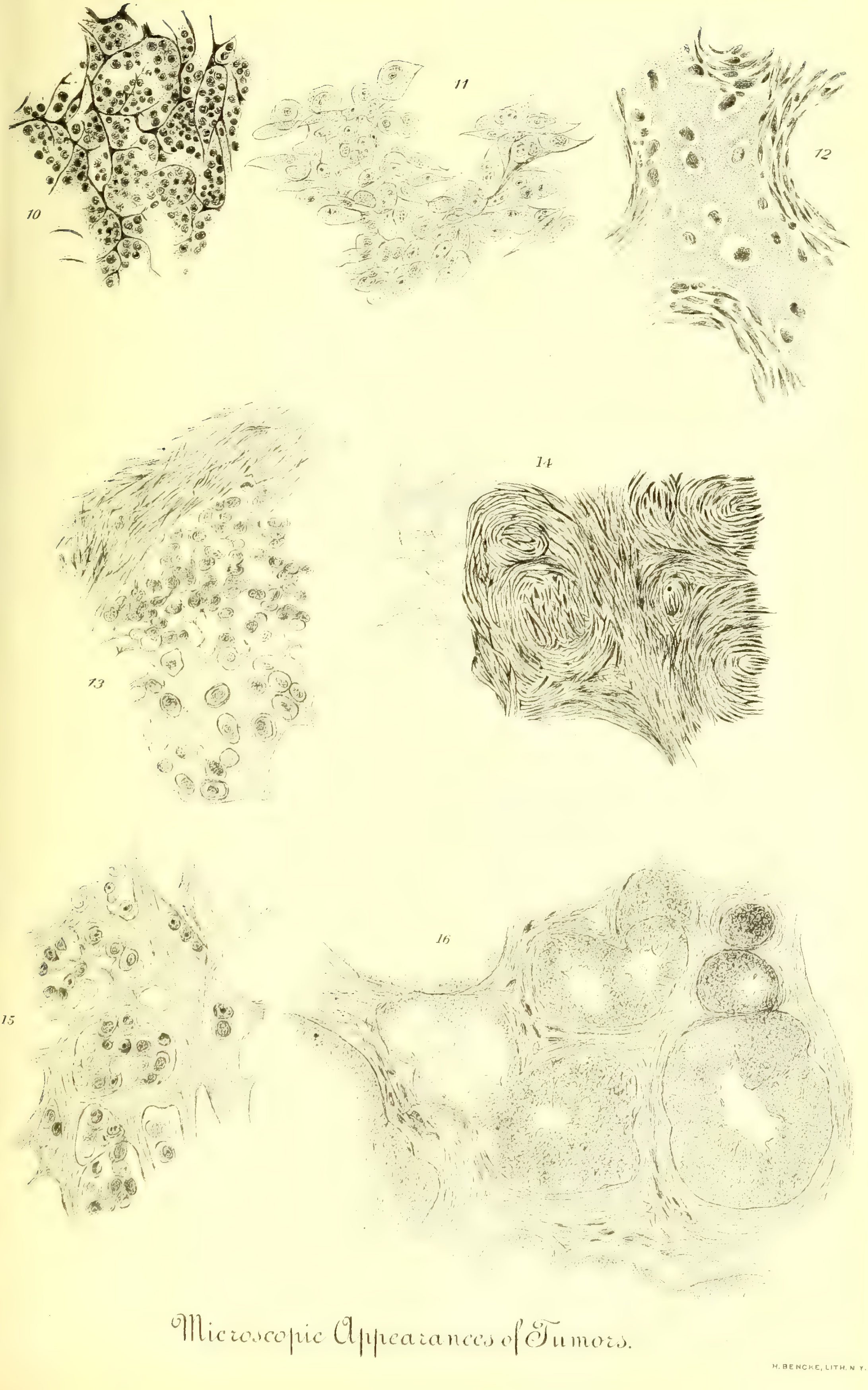
[1] Lancet, 1875, vol. i. p. 402.

[2] According to the directions given by Dr. Newman, of Stamford.

PLATE XIX.



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subcutaneous forms. The caustic is first melted on the ends of probes or wires. An incision is made in the centre of the tumor with a tenotomy-knife, and with the knife, or with a director, the tissue of the tumor is thoroughly broken up. Three or four of the coated probes are then rapidly introduced, one after the other, and the caustic soaks off from them into the interior of the tumor. Severe inflammation and, generally, sloughing ensue, and the disease is cured, but not without, in most instances, considerable scarring.

Setons of silk are used to excite inflammation in the substance of the nævus. They are often soaked before use in a solution of perchloride or subsulphate of iron. From one or two to six or more threads may be passed in different directions through the growth, at the same time. Usually, inflammation and suppuration take place along the line of each of the threads. The blood coagulates in all parts of the growth, and, after the withdrawal of the threads, a week or ten days after their introduction, the nævus slowly shrinks; but the effect of setons is very variable. They set up in some tumors so little inflammation that they are well nigh useless; the operation requires repetition many times, and a cure is only effected with the greatest difficulty. In other instances a nævus will slough completely out merely from the presence of two or three small threads; and between these extremes many gradations are observed. Nevertheless, the treatment is useful where a nævus is diffuse and tolerably bulky, and in a situation whence it cannot conveniently be removed.

Nævi may be ligatured in several different ways. The operation is employed chiefly for growths which are not deeply situated, but which are bulky. If the nævus be of small size, a thread may be tied completely around its base, so tightly that the circulation is entirely arrested in the tumor. It is usual to make a groove for the ligature before applying it, in order to diminish the subsequent pain. If the nævus be of larger size, a double thread may be passed immediately beneath it and divided into two parts, and each may be tied around one half of the base of the growth. Elongated nævi may be tied in several different portions, care being taken so to arrange the threads that each segment is thoroughly constricted, and that no intervening tissue is left untied between the segments.[1] And the larger, rounded nævi may be tied in four instead of in two segments. When the tumor appears thoroughly constricted, a puncture may be made in it to be sure that the circulation is entirely arrested. Sloughing quickly takes place, and in a few days the mass drops off, or is removed, and there remains only an ulcer which requires simple treatment. The objections to the ligature are the surrounding inflammation and often severe constitutional disturbance which it creates; the loss of skin which it entails, and the pain, which may last long after the operation. It possesses few, if any, advantages over excision, and the scar left by it is larger and more unsightly.

The cautery may be employed either to remove or destroy an angeioma. The instruments most convenient for the purpose are the benzine (Paquelin's) and the galvanic cautery.[2] The heat employed should be red, not white, for the greater heat is apt to destroy the tissues beyond the limits of the tumor, and, instead of checking, to promote hemorrhage. The cautery, as an instrument of destruction, is chiefly used for the cure of superficial nævi, or of mixed cutaneous and subcutaneous nævi of small size.

Where complete removal of a nævus can be accomplished, excision is, in most instances, the best method of treatment. When the growth is bulky and well-defined, and does not affect the integuments over a wide area, removal by the knife is the most certain means of curing the disease, and does not entail a larger or more disfiguring scar than most of the other methods which have been described. One great objection to it is the loss of blood during the operation—a loss small in quantity, perhaps, but very serious to a young child or infant. But this danger may be obviated by adopting the recommendations of Wheelhouse[1] and Davies-Colley.[2] Hare-lip pins are passed beneath the growth so as to project just beyond its margins. Beneath these an elastic band or tube (an ordinary drainage-tube will suffice) is tightly bound, so as to cut off the circulation through the tumor, which may then be dissected as entirely and carefully as may be desired. The wound may be closed and the dressings applied before the pins and elastic have been removed.

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[1] See Fig. 532, Vol. III., page 370.

[2] See Figs. 77 and 94, Vol. I., pages 504 and 524.

LYMPHANGEIOMAS, or lymphatic-vascular tumors, are not nearly as frequently observed as blood-angeiomas; indeed, they belong to the less common forms of tumor. They may be composed of a number of dilated lymphvessels, or may resemble the cavernous blood-angeiomas. The cavernous variety is the more usual. It occurs in the tongue, in macroglossia; in the skin and subcutaneous tissue, in elephantiasis; and in the lips. The disease occurs more frequently in combination than unmixed. Thus, neither macroglossia nor elephantiasis are due solely to lymphatic dilatation and disease. Certain of the congenital cystic tumors are probably lymphangeiomas, and lymphangeiomas have been described in the buttock, the thigh, and other parts. The disease is recognized partly by the plexiform or cavernous nature of the tumors, partly by the clear fluid contained in the tubes or spaces. When the walls of these tubes and spaces are examined after they have been treated (when quite fresh) with a half-per-cent. solution of nitrate of silver, it is found that they are lined with endothelium similar to that which lines lymphatic vessels. The solid tissue between them varies in quantity and character. It may be fibrous, or mucous, or fatty.

Most of the lymphangeiomas are congenital, but the disease may occur in adult life. The clinical characters of the uncomplicated lymphangeiomas are so little known that it is impossible to write a satisfactory account of them. The congenital cystic tumors which are lymphatic, do not appear to exhibit characters which distinguish them from those which are not lymphatic. In one instance in which a lymphangeioma was developed in the thigh of a child, the swelling was mistaken by Billroth for a cold abscess, and was opened. The result was a lymphatic fistula, which did not cease to flow until the tumor, which was perfectly circumscribed, was extirpated. This case deserves particularly to be borne in mind, for it illustrates the result which may follow the incision of a lymphangeioma, and still better the manner in which the disease may be treated with success.

SARCOMA OR EMBRYONIC CONNECTIVE-TISSUE TUMOR.

A sarcoma is a tumor which has its origin in one of the tissues belonging to the connective-tissue series. It consists in great part of cells embedded in a more or less abundant basis-substance. The cells multiply, usually, by division. The vessels, which are often very numerous and very thin-walled, run between the cells.

Four great subclasses of sarcoma are recognized according to the character of the cells of which they are composed: round-celled, spindle-celled, giant-celled, and mixed-celled.

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[1] British Medical Journal, 1878, vol. ii. p. 205.

[2] Guy's Hospital Reports, 1879, 3d series, vol. xxiv. p. 437.

Round-celled Sarcoma.—The round-celled sarcomas are composed of round cells embedded in a granular or homogeneous basis-substance, which is sometimes traversed by bands of fibrous tissue. (Plate XVIII. Fig. 7.) There is no definite arrangement of the cells. The vessels are often mere fissures between the cells, but more often possess a thin wall composed of a single layer of spindle-cells.

Spindle-celled Sarcoma.—The spindle-celled sarcomas consist of spindle-shaped, or oat-shaped, or fibre-like cells, generally disposed so as to form bands or trabeculæ, which cross, anastomose, and interlace with one another. (Plate XVIII. Fig. 8.) The vessel walls are formed of one or more layers of spindle-cells. Two varieties of spindle-celled sarcoma are sometimes recognized, according as the cells are very large or very small.

Giant-celled Sarcoma.—The giant-celled sarcomas are so named because a large part of their bulk is made up of flattened masses of protoplasm, containing from two or three to thirty, forty, or even more, nuclei. (Plate XVIII. Fig. 9.) These are the myeloid cells of Paget. In their most perfect and typical form they occur in the tumors of bone. The giant-cells of soft textures have, for the most part, less clearly defined outlines, less coarsely granular contents, more grotesque shapes; and those of tubercle present a peculiar disposition of the nuclei, which are generally arranged in a single row towards the periphery of the cell. Around and between the giant-cells of myeloid tumors, there are always round, oval, or spindle-shaped cells.

Mixed-celled Sarcoma.—The mixed-celled sarcomas are composed, as their name implies, of cells of various shapes (Plate XIX., Fig. 11), or are partly round-celled, partly spindle-celled. This term has been introduced in order to designate a subclass which includes a number of tumors not properly belonging to either of the preceding subclasses, on account of the irregularity of their structure.

Modified forms of these four varieties of sarcoma, particularly of the round-celled and spindle-celled, are not uncommon. Of these, the most important are the following:—

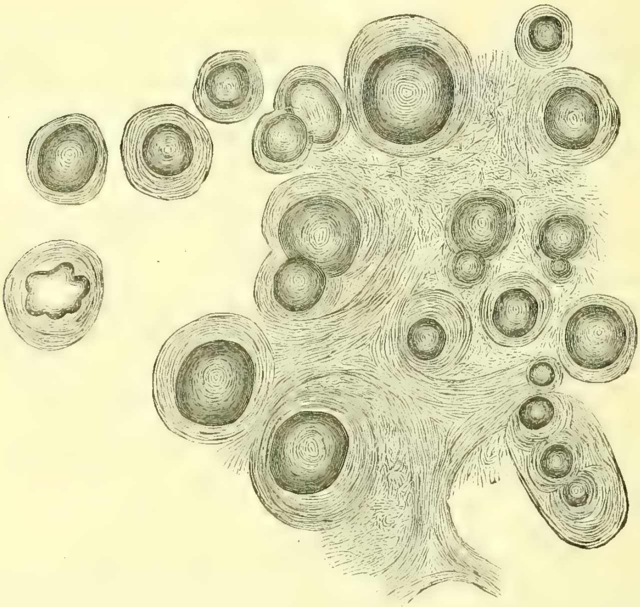
Alveolar Sarcoma.—A round-celled sarcoma having an alveolar structure somewhat resembling that of carcinoma. (Plate XX. Fig. 21.) The cells are generally of large size, and between them can often be distinguished a delicate reticulum.

Lympho-sarcoma.—The cells and reticulum resemble those of lymphatic glands. (Plate XX. Fig. 20.) The cells are, however, sometimes much larger than lymph-cells. The lympho-sarcomas usually originate in structures in which lymphatic or adenoid tissue naturally exists, but this is not an invariable rule.

Glioma.—Its structure is very similar to that of the lympho-sarcomas, but the cells are usually of smaller size. (Plate XIX. Fig. 10.) The gliomas are derived from the neuroglia or connective tissue of nerve-centres.

Plexiform Sarcoma; Cylindroma.—A round-celled sarcoma presenting the following peculiarities of structure: (1) Cylinders, or irregularly-shaped masses of cells, surrounded and separated by (2) a hyaline or very finely fibrillated substance, often very abundant; (3) a polygonal form of cells; (4) an absence of intercellular material. (Plate XX. Figs. 22 and 23.) These peculiarities of structure appear to be due to a hyaline transformation of fibrous bands or tracts of tissue throughout the tumor. The hyaline substance, occupying much more space than the tissues which it has replaced, presses asunder the intervening masses of cells, which gradually assume the appearance of cylinders or cords of cells. Owing to the pressure, the intercellular substance disappears, and the individual cells assume a polygonal form. The coats of the vessels traversing the tumor frequently undergo a similar hyaline transformation.

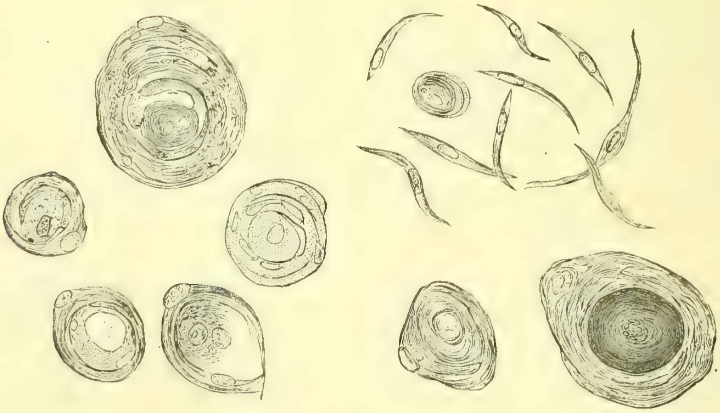
Fig. 762.



Psammoma. The central portion of each globe is calcareous. × 280. (After Virchow.)

Psammoma; Nest-celled Sarcoma; Pearl-tumor.—Not improbably, all three, associated conditions of the same variety of sarcoma. Psammoma is

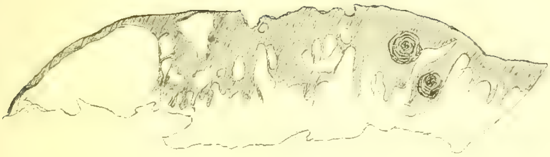
Fig. 763.



Nests and cells from nest-celled sarcoma of dura mater. × 470. (After Gowers.)

composed of bands or trabeculæ of spindle-cells or fibrous tissue, in which lie concentric bodies, containing each a central calcareous mass. The nest-celled sarcoma and the pearl-tumor consist of round, or more often of spindle-

PLATE XX.



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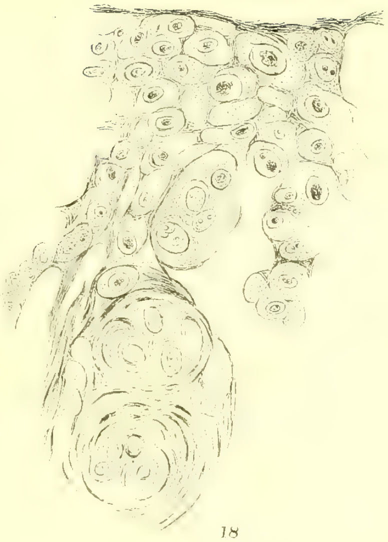

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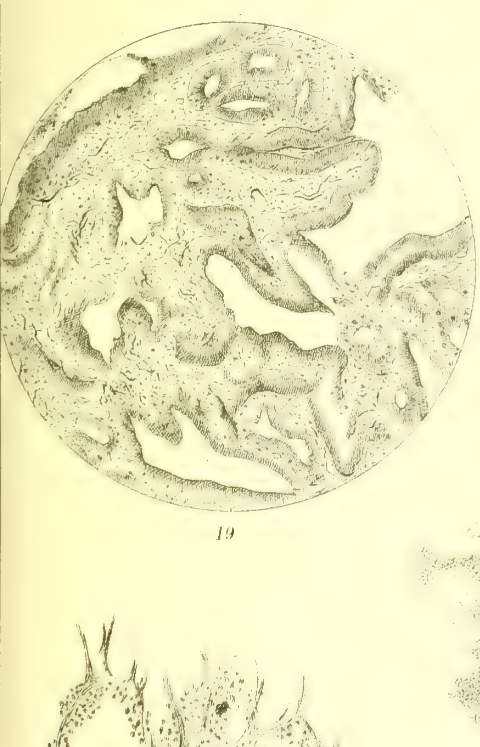

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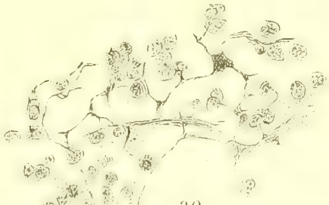

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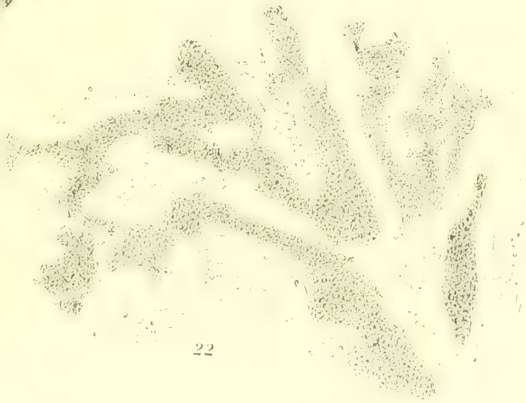

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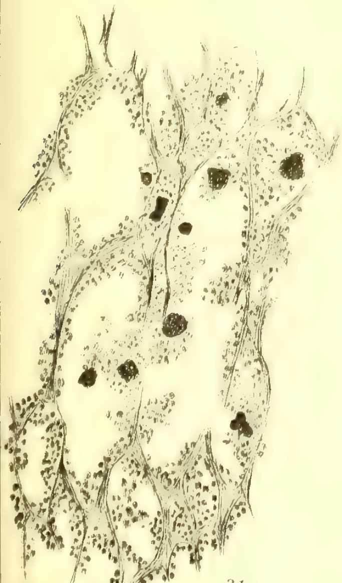

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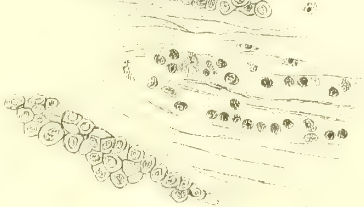

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shaped cells, with which are found cell-nests resembling the epidermic globes of squamous epithelioma.

It is probable that many, if not all, of these tumors are of endothelial origin.

Hemorrhagic Sarcoma.—A round-celled or spindle-celled tumor, having such a great tendency to bleed, that the tumor may appear to be simply a collection of blood, or a blood-cyst, so completely are its characters obscured by hemorrhage.

Melanotic Sarcoma.—A spindle-celled or round-celled tumor, in which pigment granules are so abundant that the tumor exhibits a black or brownish-black color. The pigment generally lies in the interior of the cells, but in some instances is found in the intercellular material or fibrous trabeculæ.

Myxo-sarcoma; Net-celled Sarcoma.—Most of the myxo-sarcomas appear to be spindle-celled or mixed-celled sarcomas, containing many stellate cells. The cells are imbedded in a viscid, homogeneous, or granular material, which is often very abundant, so that the tumors present a jelly-like appearance. The origin of this material is very uncertain, but it is probably a result of degeneration of some of the textures of the tumor.

LOCALITIES OF SARCOMATA.—A sarcoma may originate in almost any region of the body; for, as connective tissue is of universal occurrence throughout the body, and sarcoma is of connective-tissue origin, so the origin of sarcoma may be universal. Thus it may arise in cartilage or bone, in fibrous tissue or lymphatic tissue, in the connective tissue of the nervous cords and centres, in the connective tissue of the various organs. But in some respects it appears almost capricious in the selection of the part which it attacks. Thus, such parts as the tongue and the œsophagus, which are frequently the seat of malignant disease, are scarcely ever affected by sarcoma. The sole of the foot is not uncommonly attacked by sarcoma, the palm of the hand almost never. The bones are frequently the seat of sarcomatous growths, but certain parts of certain bones are the seats of election of the disease. Among the parts which are particularly subject to sarcoma may be mentioned the skin and subcutaneous tissue; the bones; the lymphatic glands; the eye; the upper jaw; the testicle; the breast; the brain; the lungs and kidneys. They are found also, but less frequently, in the nerves; in the fasciæ and intermuscular septa; in the spinal cord; in the heart and liver.

Further, the subclass and variety of the particular sarcoma are, to a certain extent, dependent on the character and situation of the mother-tissue. Thus, the skin and subcutaneous tissue are liable to round-celled and spindle-celled sarcomas, and the tumors are often melanotic. The bones are subject to all four subclasses of sarcoma, but the giant-celled tumors are almost limited to the central parts of bones. The lymphatic glands may be attacked by round-celled and spindle-celled sarcomas, but are most frequently the seat of the variety lympho-sarcoma. Glioma and melanotic spindle-celled sarcoma affect the eye. The testicle and breast may be the seat of round-celled, spindle-celled, and mixed-celled sarcomas, and of the variety lympho-sarcoma. The brain and spinal cord are subject to glioma; the lungs and kidneys chiefly to round-celled sarcoma and lympho-sarcoma; the fasciæ and intermuscular glands to spindle-celled sarcoma.

The influence of the mother-tissue is felt not only in determining the form of sarcoma which is primarily produced, but in the transformations or degenerations which the tumor undergoes. Thus, the subperiosteal sarcomas are peculiarly liable to osseous and calcareous changes, and fibrous tissue is largely found in tumors which grow from the fasciæ and septa. Nor is this influence limited to the primary growth. It makes itself felt in recurrent and secondary tumors, which preserve not only the general characters of the primary disease, but even the transformed or degenerated characters which it presented. The chondrifying sarcomas of the testicle are, by this means, repeated in the glands and lungs; the ossifying subperiosteal sarcomas, in the lungs; the melanotic sarcomas of the eye, in the substance of the liver.

That a sarcoma should take its origin in connective tissue has been laid down in the definition as essential. But the precise element of the tissue from which it is developed has not yet been demonstrated. That it is of cellular origin is almost certain. But whether it arises from wandering blood-corpuscles, from endothelium, or from the fixed cells, is still an open question. My own belief is strongly in favor of the theory of origin from the fixed connective-tissue cells, if not in all structures, at least in many. The theory of origin from wandering corpuscles, carries with it, almost of necessity, the belief that the tumor commences in the lymph-spaces through which these cells may be assumed to travel; and, therefore, that the tumor has free access to the lymphatic vessels with which these spaces are in communication. If this were so, the glands ought almost invariably to be affected by sarcoma. But glandular affection is not by any means an invariable occurrence. Nor do I think that the characters of what must still be spoken of as the mother-tissue would be so strongly impressed upon a tumor which originated from cells which may be regarded as indifferent, and of merely accidental occurrence in the mother-tissue. The same reasoning, as far as the lymphatics are concerned, would lead me to deny that the origin of any sarcomas was from the endothelium lining lymphatic spaces. Yet I can quite conceive that sarcomas of such parts as the testis, which certainly and early affect the glands, may arise from endothelium. In cartilage, it is probable that the tumor arises from proliferation of the cartilage-cells; in bone, from the corpuscles of the marrow and soft tissue in the cancellous spaces, or from the cellular elements of the periosteum.

Course of Sarcomata.—Sarcomas frequently grow rapidly, but their rate of increase is subject to remarkable variation. The situation of the tumor necessarily exercises some influence on the manner and rapidity of its growth. Tumors of parts which are loose-textured and abundantly supplied with blood, naturally grow more quickly than tumors which are poorly nourished and confined in narrow spaces. The increase is effected by continual addition to the surface, or rather by the continual invasion of the surrounding tissues by the new growth in the manner described in the introductory portion of this article. The capsule which incloses many specimens of sarcoma does not prevent them from spreading. They infiltrate the capsule, and extend into or affect the surrounding tissues.

Sarcomas may occur at any period of life. Congenital tumors are occasionally met with; children are not unfrequently the subjects of sarcoma; persons in middle life are frequently attacked; and old people may fall victims to the disease in their eighth or ninth decade. Although children are not as subject as adults to sarcoma, sarcoma is nevertheless *the* malignant disease of childhood, for carcinoma is scarcely ever observed in children. Both sexes appear equally liable to the disease, but of course its seat is often largely influenced by sex.

Appearances after Removal.—The *macroscopic characters* of sarcoma are so manifold that it is impossible to cover them with any general description. The fact that the tumors are often surrounded by a capsule, has just been mentioned, and must be looked on as a somewhat singular circumstance in a disease which is unquestionably malignant, and which, in many instances, expresses its malignancy chiefly or only by its continuous extension. The presence of a capsule is not, however, constant. Sarcomas of the bones, and those of organs like the testis, possess no special capsule, but the latter are, of course, contained for many months, or even years, within the tunica albuginea or tunica vaginalis, which has thus the appearance of a capsule proper to the tumor. Some rapidly growing sarcomas of large size present all the characters of typical encephaloid disease. They are white, opaque, soft, and juicy; and streaked, or dotted, or blotched with blood. Some are quite as soft and juicy, but exhibit a slaty color. Some look, when cut, like the substance of a ripe plum or nectarine, juicy, semi-translucent, and yellowish-white, or deep yellow dashed with red. Indeed, there is scarcely an appearance among morbid growths which a sarcoma may not exhibit; for, in addition to the multiplicity of characters which may belong to the pure specimens, the disease is so often complicated by the mingling of other tissues, that almost every kind of innocent tumor may be imitated by sarcoma. Probably the appearance of a withering carcinoma is less often observed than any other. In some parts of the body there is little or no difficulty in distinguishing, from the macroscopic characters, between carcinoma and sarcoma. In the breast, the absence of capsule, and of large cysts with intra-cystic growths, are alone sufficient to characterize carcinoma. And, when the carcinoma is contracted or disseminated, there is no difficulty in deciding between the two diseases. In other parts of the body it is impossible, unless by the chance admixture of some tissue, such as cartilage or bone, with the sarcoma, to distinguish between sarcoma and carcinoma. The tumors of the testicle afford an admirable illustration of this difficulty of diagnosis. The round-celled, spindle-celled, and mixed-celled sarcomas cannot usually be respectively distinguished in any part. The spindle-celled tumor does, however, sometimes present a fasciculated section, but this is not constant or reliable. But the typical myeloid or giant-celled tumor is firm, close-textured, and colored like the muscular substance of the mammalian heart. Its characters are quite unmistakable.

The *microscopic characters* of sarcoma have been described in the definitions of the sub-classes and varieties. It must be borne in mind that, whereas they are generally so characteristic that they can scarcely be confounded with the minute structure of any other disease, yet some specimens are exceedingly perplexing. The resemblance of round-celled sarcoma to granulation-tissue, or inflamed tissue, is often most striking, nor do I think that, in every instance, the diagnosis can be made. (Plate XVIII. Fig. 7.) Again, lympho-sarcoma may be so exactly similar in appearance to hypertrophied lymphatic gland, that the minute appearances alone are not to be relied on for the diagnosis. Alveolar sarcoma sometimes presents the appearance of carcinoma, but usually the diagnosis is not difficult, for the walls of the alveoli are often formed of spindle-cells, and the contents are rarely so uniform and epithelioid in character as the contents of the alveoli of carcinoma. The real nature of a hemorrhagic sarcoma is not easy to discover. The tumor may be so largely composed of blood that it may be taken for a cyst. Many of the so-called blood-cysts are tumors of this description. To detect the presence of sarcoma in them, a very careful examination is required. Usually, round-celled or spindle-celled tissue is present in sufficient quantity in the rough wall of the cystoid cavity to furnish evidence of the presence of sarcoma; and, in addition, trabeculæ of spindle-cells may, in many instances, be discovered traversing the blood in various directions.

METAMORPHOSES AND COMBINATIONS.—Sarcoma is liable to many transformations of its structure. It may undergo fatty or caseous degeneration, the result of which is that many sarcomas contain areas, or streaks, or masses of cheesy substance. The more cellular and the less vascular the tumor, the greater is the tendency to caseous degeneration. Organization into fibrous tissue, cartilage, and bone, is exceedingly common in the tumors of certain parts. Fibrification may take place in the tumors of almost every part; on a large scale it is more frequent in those of the fasciæ and intermuscular septa. Chondrification is not uncommon in the sarcomas of the testis, and is very common in those of bone. (Plate XIX. Fig. 13.) And ossification is of very frequent occurrence in subperiosteal sarcomas (Plate XIX., Fig. 12), sometimes transforming the greater portion of a tumor into bone, sometimes only forming bony spiculæ, or an imperfect and fragile bony skeleton. The calcification of subperiosteal tumors is almost as frequent as their ossification; the distinction is not apparent to the naked eye, but is evident in microscopic sections, when the lacunæ and canaliculi of ill-developed bone may be observed in the ossifying tumors. Mucous transformation is observed in sarcomas of the breast, the testis, and the nerves, and in those of the salivary glands. The mucous and fatty transformations may lead to the formation of cystoid cavities. Some of the large mixed-celled sarcomas of the bones are remarkable for the size and number of these cavities, most of which, probably, derive their origin from mucous transformation of the tissues of the tumor. These different changes in sarcomas are productive of much inconvenience in classification, for a sarcoma is liable to be so altered in appearance by them, that it may be mistaken for a growth of an entirely different character. This matter was referred to in the preliminary portion of this article, and the necessity was there pointed out of distinguishing clearly between these metamorphosed tumors and the growths which they most resemble. For this purpose an examination of the youngest portions of the tumor must be made, and, when possible, of recurrent and secondary growths. The method of classifying many of these tumors separately, as osteoid cancers, osteoid sarcomas, and osteo-sarcomas, was also objected to. The principle is incorrect, and the nomenclature is misleading.

In connection with mucous transformation, must be mentioned the possibility of colloid transformation of sarcomas. This has been so long regarded as a change only befalling carcinoma, that it seems difficult at first to admit that sarcoma may be also liable to it. Yet, apart from the close relation which probably exists between mucous and colloid changes, there seems no reason why the cells of a sarcoma should not undergo the colloid change. There can be no doubt that conditions which are indistinguishable, or scarcely to be distinguished, from those observed in colloid carcinoma, may befall certain sarcomas. An admirable illustration of such a case may be found in the Transactions of the London Pathological Society,[1] where a multiple sarcoma of bone presented all the characters of colloid carcinoma. The disease was, indeed, described as colloid cancer, but the origin of the tumors in the interior of the bones forbids the idea that they were truly carcinomas.

Although the transformations of a tumor must be regarded as secondary changes, they are, nevertheless, in many instances, as essential to it as its proper primary structure. They affect a large portion of its tissues; they are repeated in recurrent and secondary growths in distant parts. The tenacity with which they adhere to the disease throughout its course, is observed in the pigmented (melanotic) sarcomas, and in the hemorrhagic and organizing growths. The practice of noticing the transformations of a sarcoma in its name, has on this account some ground to justify it. Nor, as long as the terms employed are simple and intelligible, can there be any serious objection raised against it. A sarcoma may be named an ossifying, or calcifying, or fibrifying sarcoma, without obscuring its real nature. The term hemorrhagic, applied to a sarcoma, does not lead to confusion. But the term melanotic is not wholly free from objection, for there is a tendency to attribute to melanotic sarcomas properties which the uncolored tumors do not possess. The term pigmented is, on the whole, to be preferred, since it does not carry with it any further meaning or false impression. The terms osteo-sarcoma and osteoid sarcoma are absolutely indefensible.

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[1] Trans. Path. Soc., vol. xxii. p. 206.

Some of the so-called transformations of sarcomas may be, and probably are, true combinations of sarcoma with other structures. Thus mucous tissue, cartilage, bone, and fibrous tissue, may all or any of them be combined with sarcoma, without necessarily having resulted from organization or degeneration of the natural tissues of the tumor. One of the most certain combinations is that of gland tissue with sarcoma. It occurs in such organs as the breast, where, with the formation of sarcoma-tissue, there takes place simultaneously a development of acini and tubes from the previously existing glandular structures. It must be borne in mind that the combinations of glandular and other tissues with sarcoma are of very little clinical importance, for they exercise little or no influence on its course. However large the proportion of the developed tissue compared with the quantity of sarcoma-tissue present, the destructive power of the tumor will always depend on the sarcoma-tissue. In spite of the less settled character of the latter, its hold upon the individual is far greater than that of the developed tissue. The latter exercises no softening or benign influence on the sarcoma-tissue, but the sarcoma-tissue may, as it were, poison the more developed growth.

Nevertheless, the combinations with other tissues often produce great alterations in the characters of a sarcoma. Even the combinations with glandular tissue, though not at first as evident as those with bone, or cartilage, or fibrous tissue, may in time lead to macroscopic changes quite as striking, owing to the formation of cysts. The large cystic sarcomas of the breast are familiar to every practical surgeon, and sarcomas of the testicle containing cysts are scarcely less familiar. The formation of the cysts in these tumors from the glandular structures of each organ has repeatedly been traced, and at the present moment is hardly disputed by any pathologist.

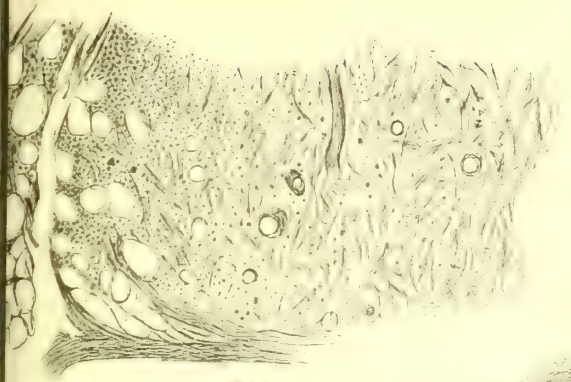
Sarcomas are prone to inflammation, and, but much more rarely, to suppuration. The signs of inflammation are sometimes so strongly expressed in connection with a quickly growing sarcoma, that the question of diagnosis may be affected. In some of these cases, the rapidity with which the tumor grows may suffice to explain the heat and pain of which it is the seat. In other cases the tumor actually becomes the seat of inflammation, or sets up inflammation amid the surrounding tissues. A sarcoma may ulcerate, and the character of the ulcer is, in some instances, significant of the nature of the disease. It is not merely a superficial opening through the skin, due to pressure, or to irritation and inflammation of the tumor, but the structures covering the tumor are, as in carcinoma, gradually infiltrated by the growth until the skin is transformed into sarcoma-tissue. The ulcer, when it forms, is then a cavity bounded on all sides by the tumor substance, out of which it may appear to have been scooped. But the surface of the ulcer sometimes puts forth large and prominent granulation-masses, so that there is a protrusion in the place of a depression. This is particularly noticeable in the cystic sarcomas of the breast, where a superficial cyst becomes filled with intra-cystic growth; the skin covering the cyst at length gives way, and with it the cyst-wall; and through the circular opening thus formed, the intra-cystic growth, still enlarging, protrudes as a soft, fungous mass, prone to bleed and slough. Around such a mass as this the skin is not generally adherent, but is thin and undermined; it has not been invaded by the growth, but has given way from pressure.

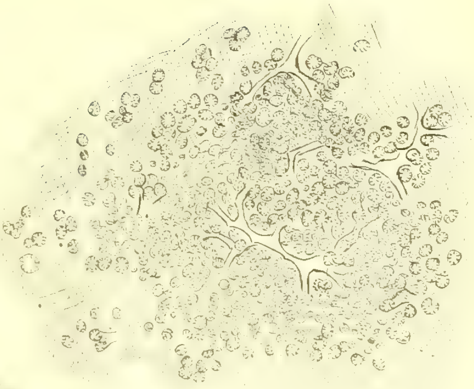
Sarcomas occasionally, but very rarely, slough completely out and undergo spontaneous cure. I have seen one of several tumors in the back of a boy's thigh, thus perfectly removed, nor was there any recurrence, although the patient lived more than a year after this accident. It is, however, more usual for a large fragment of a tumor to slough out without benefit to the patient; and still more rare than sloughing, is spontaneous cure by the gradual withering of a tumor. Indeed, a sarcoma rarely, under any circumstances, diminishes in bulk. In the patient of whom mention has just been made, a tumor of the testicle decreased notably in size during the course of weeks or months, but the progress of the disease was not arrested. During this period the pelvic glands were steadily enlarging, and, although the testis diminished, it did not regain its normal size or consistence.

Symptoms of Sarcomata.—To give a general description of the clinical characters which shall apply to all sarcomas, is impossible, for no class of tumors is so liable to variation. So much depends on the situation of the growth and other associated conditions. Yet there are certain characters which are sufficiently general and important to be noticed in this section. That a sarcoma may be as hard as bone or as soft as jelly; that it may grow slowly or may increase with rapid strides; that it may be very smooth or very uneven; that it may be movable or fixed, are characters which might be expected from what has been already said of this disease. Indeed, it is difficult to imagine characters which a sarcoma may not present. But a combination of symptoms is often observed which is very characteristic of sarcoma. Multiple tumors, not secondary to one among their number, affecting different yet nearly allied tissues, increasing steadily and often rapidly, invading neighboring structures and becoming speedily less movable even when they are of small or moderate size, without signs of inflammation, yet tending to produce discoloration of the integuments over them—can scarcely be other than sarcomas. Unequal consistence, rapid growth, the absence of signs of inflammation, the occurrence of the tumor in one of the well-known seats of election of sarcoma, and increasing immobility, are probably the most characteristic symptoms of the disease. But every one of these symptoms may be absent, and yet the disease may be a well-marked specimen of sarcoma. In the sketches which will presently be given of the sarcomas of certain tissues and organs, the most important features of each will be described, and at the same time attention will be drawn to the characters upon which most weight should be placed in making a diagnosis.

Prognosis.—The prognosis of sarcoma is never favorable. The sarcomas of some parts are quickly fatal, and this, not because the disease primarily attacks vital structures, but because of its essentially malignant nature; thus, subperiosteal sarcomas of the bones run usually a very rapid course, and, becoming generalized, sometimes kill in three or four months. Sarcomas of the foot are also very malignant, and sarcomas of the tonsil more so, perhaps, than primary sarcomas of any other part. The manner in which the disease invades surrounding parts has been already spoken of, and the fact that it often—nay, almost always—oversteps its apparent limits (that is, its capsule), and grows, microscopically, in the tissues just beyond. (Plate XXI. Fig. 24.) Thus is accounted for the recurrence of sarcomas, the intense obstinacy with which some of them are re-formed, not once but many times. A tumor, perfectly encapsuled, shells out with ease; the capsule is not opened, so that there appears no reason to believe that any of the tissue of the growth has

PLATE XXI.





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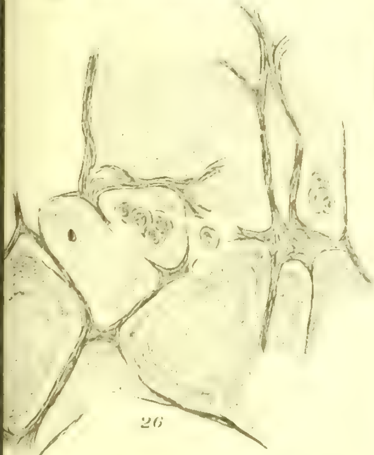

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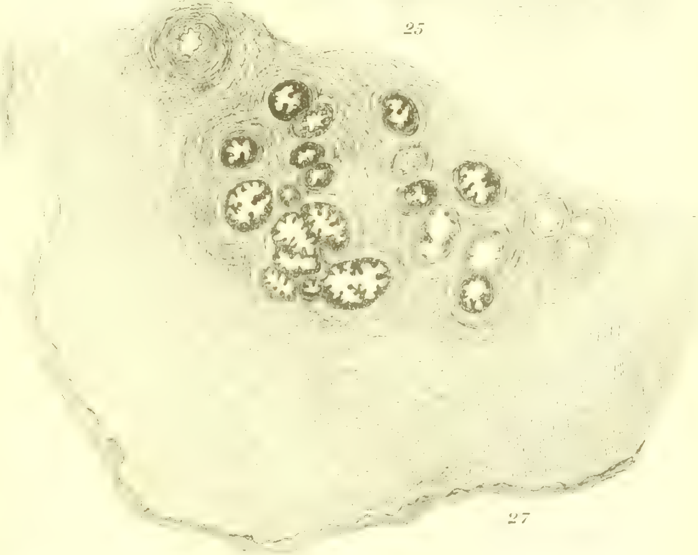

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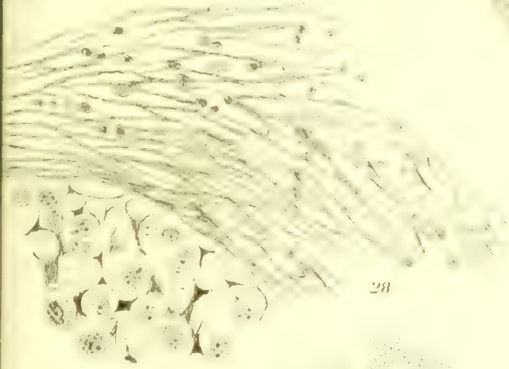

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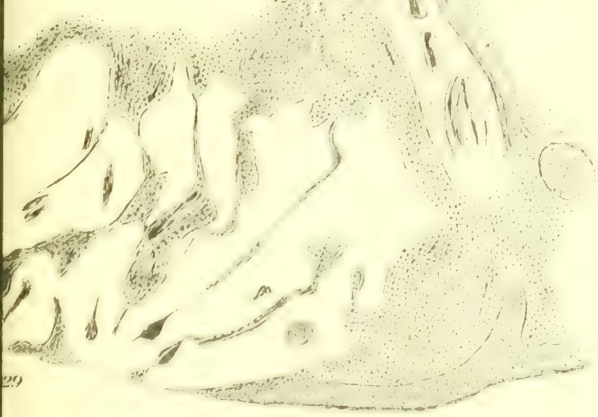

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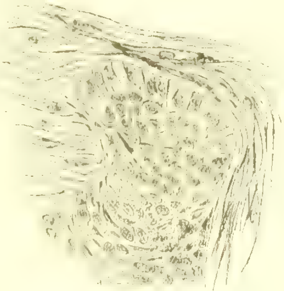

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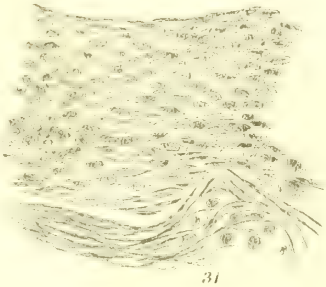

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Microscopic Appearances of Tumors

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been inoculated in the wound; healing occurs rapidly and completely; but in less than six months the growth appears in, or in the immediate vicinity of, the scar. The completeness of the removal was but apparent; an area of the tissues immediately around the capsule, tissues unquestionably affected, ought to have been sacrificed.

Multiplication and Recurrence.—But the malignancy of sarcoma is not limited to this local infection. The disease may affect the lymphatic glands. Contrary to the general teaching on this point, the glands may be affected as early and as certainly by sarcoma as by carcinoma; nor is there at present any evidence to prove that the manner in which the affection is produced is different in the two diseases. The glandular affection in sarcoma depends, not on a special malignancy of individual tumors, but on the seat of origin of the disease. Thus, sarcomas of the eye, the upper jaw, the bones, the larynx, and the breast, rarely or never affect the glands. But those of the foot, the tonsil, the testis, and, probably, the kidney, affect the glands certainly, and in most instances early. In connection with this subject, two points require elucidation: first, the reason why the sarcomas of certain parts affect the glands, while the sarcomas of other parts do not affect them; second, the reason why the glands are occasionally affected by sarcomas which do not habitually affect them. The answer to the first question may be sought in several circumstances, such as the subclass or variety of sarcoma, the absence of lymphatics in certain parts, and the precise origin and manner of growth of the tumor. The subclass or variety of sarcoma does not appear to exercise the slightest influence on glandular affection. Every kind of sarcoma which attacks the testis affects the glands, and the peculiarities of the primary tumor are almost invariably repeated in the tumors of the glands; on the other hand, not one of the subclasses or varieties of sarcoma of the breast or upper jaw affects the glands. Nor can the tendency to, or freedom from, affection of the glands depend chiefly on the presence or absence of lymphatics in the part primarily diseased, for certain of those parts which are not associated with glandular affection are largely provided with lymphatics—the breast for example. That the course of the disease may be influenced by the absence of lymphatics, cannot, of course, be questioned. Indeed, it seems quite possible that the freedom of the glands from secondary affection in primary sarcoma of the bones, may depend on the absence of lymphatics from the osseous system. It is, however, premature to speak too decidedly on this point, for the proof may yet be forthcoming that the bones are provided with lymphatics. The certainty and speed with which the glands are diseased in connection with sarcomas of certain bones (those of the foot) tend to prove that there must be a close relation between the lymphatics and these bones. The exact origin of the primary tumor, however, and the manner of its growth, are the conditions to which we must look for an explanation of the affection of lymphatic glands in cases of sarcoma. Those tumors which do not affect the glands must originate in elements of the part which are not in direct communication with the lymphatics, and the new growth, instead of making its way into the lymphatic capillaries, must rather close them in its progress. Those tumors which affect the glands must originate in elements, which, if not actually within the lymphatics, have free access to them. The absence of glandular affection in connection with the sarcomas of certain organs, is the more noticeable on account of the certainty with which the glands become affected by carcinomas of the same organs. The breast and larynx may be used to illustrate this point.

The second question is almost more difficult to answer than the first. Sarcomas of the bones, with the exception of the tumors of the tarsus, and, perhaps, of one or two other bones, do not affect the glands; yet sometimes it happens that a sarcoma, especially a subperiosteal tumor of the femur, or of the clavicle, is the cause of extensive glandular affection. I have endeavored to explain this by supposing that the primary disease in these cases has gradually grown into neighboring lymphatic glands, and thus has gained an entrance into the lymphatic system.[1] And this appears the most reasonable explanation. It does not suffice to assume that the disease spreads from parts which are not provided with lymphatic vessels, into parts in which these vessels are numerous; for, if this were so, affection of the glands ought to occur in every case in which the disease extends into the soft parts around the bones. But such is not the fact.

The malignancy of sarcoma may be still further expressed by the affection of distant tissues and organs. It is especially prone to affect the lungs and pleuræ, and it also attacks the heart, liver, kidneys, spleen, distant and disconnected lymphatic glands, brain, bones, muscles, and subcutaneous tissue. Indeed, most of the tissues and organs which are subject to primary sarcoma are also subject to secondary growths. As exceptions to this rule, the eye, the breast, and the upper jaw, may be mentioned. The seat, frequency, and period of formation of secondary tumors are liable to immense variation. Primary tumors of the same tissue or organ, apparently identical in structure, form, and manner of growth, occurring in two persons of equal age and equal strength, may yet be followed by secondary tumors of dissimilar parts, after very different intervals of time. Whether the difference lies in some unnoticed, and at present undiscoverable, difference of constitution of the subjects, or in an indistinguishable but essential difference in the primary tumors, it is impossible to say. The disease in most instances is conveyed through the medium of the blood, probably, in the form of germs which are capable, on reaching a suitable soil, of developing into sarcoma-cells, or which, perhaps, excite, as by spermatic influence, a formative action in the cells of certain parts, with the result that the excited cells bring forth new cells of the sarcoma type. How the germs, which are probably very minute, are arrested when a part suitable for their development or action has been reached, is not easy to understand. Nor is it easy to understand why certain tissues and organs should be selected, while other tissues and organs, of equal or greater importance and vitality, are rejected. Mere vascularity does not attract, for the most vascular tissues of the eye are never the seat of secondary tumors. Nor are very cellular regions especially liable to secondary tumors; the spleen, for example, and the salivary glands. Nor does resemblance of structure to the tissue primarily attacked render tissues much more liable to secondary growths: thus the secreting glands are very rarely the seat of secondary tumors, even when the primary disease is seated in one of them. But several of these conditions, with small size of capillaries and a very important additional condition—opportunity—probably have much to do with the occurrence of secondary growths. The small size and great number of the pulmonary capillaries, and the splendid opportunity afforded them of obtaining sarcomatous material by reason of the relation of the pulmonary circulation to that of every portion of the body, are conditions which may easily account for the great liability of the lungs to secondary growths. But this same factor, opportunity, cannot be charged as the only or chief cause of the formation of all secondary tumors For parts which, in all physiological probability, enjoy an equal opportunity of obtaining sarcomatous material, are very unequally affected. The liability of a tissue to be affected, must depend still further on the suitability of the soil which it offers for the reception and development of the malignant germs.

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[1] Sarcoma and Carcinoma, pp. 46 and 112.

Treatment of Sarcomata.—In the treatment of any given case of sarcoma, the freedom of the glands and distant parts from the disease must of course be proved and taken into account. Further, the necessity of wide removal of the primary disease must be borne in mind. Speaking in general terms, early operation is advisable for all sarcomas which admit of very complete removal, and is even justifiable in some instances, in which there is irremediable affection of the glands; when, for instance, the primary tumor can be thoroughly removed, and its presence is associated with excessive pain and infinite distress. An operation under these circumstances may be followed by a few months of ease. The result of operation depends largely on the situation of the tumor. Even amputation high above the disease in some situations, while it affords certainty of freedom from recurrence of the primary tumor, offers little or no hope of cure; for the course of the affection is so rapid that, apparently within a few weeks of the first appearance, distant tissues and organs are already affected.

To complete this general sketch of sarcoma, some mention must be made of the distinctive characters of the four subclasses.

The *round-celled sarcomas* may be regarded as the least developed of the four, for the tissue of which they are composed most closely resembles embryonic or granulation tissue. They affect the subcutaneous tissue and the bones; the eye and the brain; the lymphatic glands and the tonsil; the kidney and the testis. They may occur at any time of life, from early infancy to advanced old age. They grow usually with rapidity, and quickly invade the surrounding tissues. They are often not encapsuled, and they form the most diffused tumors of all sarcomatous growths. By this character, together with their greater softness and friability, and their lack of fibrillation, they may be distinguished from sarcomas of the other subclasses. They are prone to undergo fatty and caseous degeneration, and may calcify or be organized into fibrous tissue, cartilage, or bone. But the tendency to organization is small, and, in the tumors of certain parts—the eye, the brain, the lymphatic glands, and the kidney—is almost absent. Nor are combinations of round-celled sarcoma with other tissues frequently observed. Round-celled sarcomas are not uncommonly multiple; and, when they are so, they affect chiefly the glands, the bones, and the subcutaneous tissue. The prognosis of round-celled sarcoma, all other conditions being equal, is worse than that of either of the other subclasses. The rapidity of growth and local infection is proportionately great; dissemination takes place early, widely, and with great rapidity. The structures in which multiple tumors are usually observed are frequently the seat of secondary growths; and with them may be mentioned the liver and the walls of the intestines, in which secondary growths sometimes occur in large number.

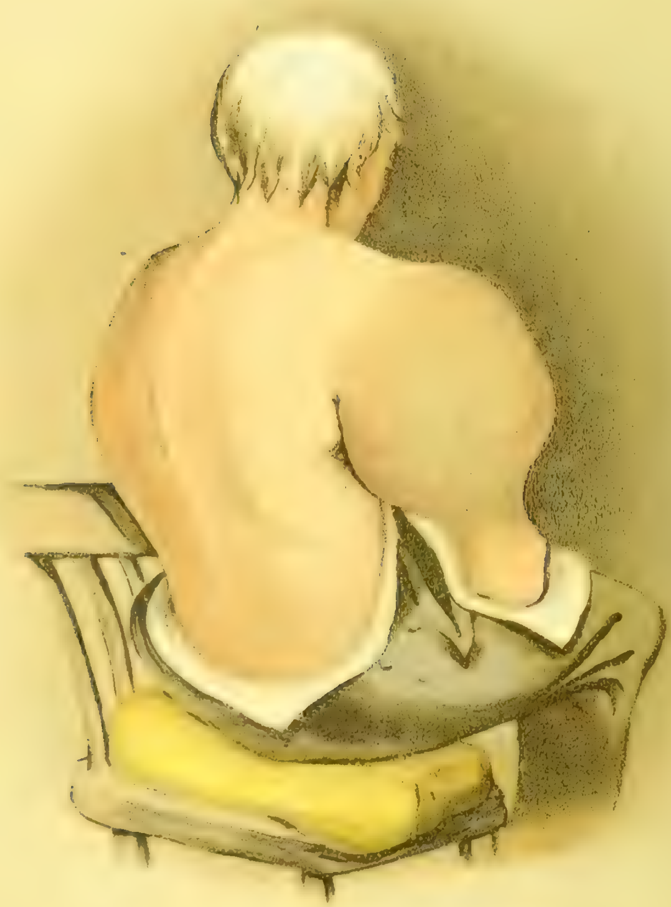
The *spindle-celled sarcomas* are usually held to be composed of more highly developed tissue than the round-celled, in the same measure as a spindle-cell or fibre-cell is regarded as one stage nearer than the round cell to perfectly developed fibrous tissue. Certainly the tendency to develop into fibrous tissue is much more powerful in spindle-celled than in round-celled tumors. And, with the changed form of cell which marks the higher development, some traits of the savage malignancy which stamps the round-celled tumors appear to have been lost; for, as a class, the spindle-celled tumors are less active than the round-celled. They form in the skin and subcutaneous tissue, the fasciæ and aponeuroses, the nerves, the bones, the breast and the testis, and more rarely in other parts which are subject to sarcoma. Their occurrence, like that of the round-celled tumors, is not limited to certain ages, but they are much more common in persons who are not placed at the extremes of life. If they occur in children, it is more often in older children than in infants, and they seldom attack old people of either sex. They are often encapsuled, and the capsule may be thick, strong, and complete. They frequently present, on section, an aspect resembling that of fibrous and muscular tumors, for the bands of small and closely set spindle-cells look, to the naked eye, like bands of fibrous tissue. They are, too, usually of firmer texture than the tumors of the last subclass. But these characters are not always present, and a spindle-celled sarcoma may be soft, homogeneous, and quite brain-like. The spindle-celled tumors not only tend to organization into fibrous tissue, but into cartilage and bone, and they are subject to all the degenerations which affect sarcomas. True cysts are more often formed in connection with spindle-celled than with round-celled tumors; indeed, in the breast and testis they occur almost invariably in connection with the spindle-celled tumors. Multiple spindle-celled tumors occur in the skin, where they are often pigmented (melanosis), in the nerves, and more rarely in other structures. The growth of spindle-celled tumors is not usually as rapid, nor is their dissemination as widely spread as that of the round-celled tumors; but it must not be supposed that there are not exceptions to this rule. The parts most frequently attacked by secondary growths, not taking into account glandular affection, are the lungs and pleuræ, the skin, and the subcutaneous tissue.

The *mixed-celled sarcomas* may be met with in many of the parts subject to sarcoma, but the best examples are observed in connection with the bones. Here, not only are the tumors composed of cells of several shapes, but many tissues may be mingled in strange confusion to make up the tumor: fibrous tissue, bone, and cartilage, with sarcoma-tissue, calcifying or becoming fatty. In these tumors large cystoid cavities frequently occur, true cysts much more rarely. The mixed-celled tumors are usually very malignant, and secondarily affect the lungs, perhaps more often than any other organs.

The *giant-celled or myeloid sarcomas* are the least malignant of the four subclasses. They are almost limited, as primary growths, to the interior of the bones, and exhibit a marked predilection for the lower jaw, the femur, and the tibia. Giant-celled tumors have also been observed in the testis, the breast, and other of the soft structures, but the giant-cells of which these tumors are composed are very different in character from the giant-cells of the central tumors of the bones, and their origin is probably very different. A sarcoma should not be termed giant-celled unless the giant-cells constitute at least half its bulk. The giant-celled tumors seldom occur at the extremes of life; they are more frequently met with before or about the middle period. They grow for the most part slowly. I have seen a myeloid tumor of the lower jaw no larger than a small walnut at the end of seven years. They are not generally encapsuled, but are usually perfectly circumscribed, and surrounded by the cortex of the bone. Most of them are firm-textured, homogeneous, and red or brown in color. They are less prone than the other sarcomas to organization, and not very prone to degeneration. Occasionally cystoid cavities form in them. Myeloid tumors are rarely multiple and rarely disseminated, but multiplicity and dissemination may both occur.

The want of sufficient space will not permit even a short, separate account of the sarcomas of every locality which these tumors affect. But an account of some of them is highly desirable, if not absolutely necessary, to prove how largely the disease is influenced by the situation of the primary growth.

PLATE X



Sarcoma of humerus and scapula

Sarcomata of Bone.—The *bones* are subject to every one of the four subclasses of sarcoma; and, although each subclass preserves within certain limits its individuality, the whole disease is marvellously modified, not only by occurring in connection with the bones, but even by the particular bone and part of the bone which is affected. First, *subperiosteal* tumors are, other things being equal, very much more malignant than *endosteal* or *central* tumors. Second, tumors of bones more near the trunk are, with few exceptions, more malignant than tumors of more distant bones; thus, tumors of the humerus are more malignant than tumors of the radius and ulna, and tumors of the femur than tumors of the fibula and tibia. An exception must be made for tumors of the tarsal bones, which appear much more malignant than those of the bones of the leg. Both the central and the subperiosteal tumors attack the long bones more frequently than those of other shapes, and the femur more frequently than any other bone. And both have a marked predilection for the ends of the bones, but the predilection is much stronger in the central tumors. They affect the upper end of the humerus (Plate XXII.) and lower end of the radius and ulna; the lower end of the femur and upper end of the tibia and fibula. Both central and subperiosteal tumors attack the flat bones—the scapula, the sternum, and the calvaria. But the short bones are very seldom affected.

The bones of children and old people may be the seat of sarcoma, but the disease is much more common during middle adult life. As a general rule, central tumors attack older persons than subperiosteal tumors. Both sexes appear very nearly equally liable to sarcoma of the bones. Neither the central nor the subperiosteal tumors are usually surrounded by a capsule, but the former are for a long time inclosed in the expanded cortex of the bone, and, when that is broken through, in the periosteum; and the latter are completely covered by the periosteum until they have attained a considerable size and have grown through it, when it may still be discerned as a curved line of tough fibrous tissue, sometimes ossified, traversing a section of the tumor. The macroscopic characters of both the central and subperiosteal tumors are variable within wide limits, the more so on account of the organizations and degenerations to which the subperiosteal growths, especially, are prone. Cystoid cavities may be formed in both, and both may undergo fatty and mucous transformations; but chondrification, ossification, and calcification, are far more often observed in the subperiosteal tumors, undoubtedly by reason of the influence exercised by the presence of the periosteum.

Subperiosteal Sarcomata of Bone.—The *clinical characters* of the subperiosteal tumors are the situation they affect, their general tendency to assume a fusiform or clavate shape, their unequal consistence, and often irregularity of surface. They seldom enlarge a bone equally in all directions, but more often produce great swelling on one aspect, little or none at all on the opposite side. They grow, for the most part quickly, often with astonishing rapidity, and the rapid growth is sometimes accompanied by well-marked signs of inflammation—heat, and even redness of the surface, with excessive pain and tenderness. The pain occasionally subsides, and recurs in paroxysms of great severity, during which the bodily temperature may be raised several degrees. However large the tumor, and however closely it approaches the neighboring joint, the joint itself is rarely invaded. The growth tends rather in the opposite direction, and may occupy, in course of time, half or two-thirds of the length of the affected bone. At the same time it gradually grows towards the surface, and may in time ulcerate and fungate, an occurrence never very frequent, and rare in sarcomas of the more deeply-seated bones.

The *diagnosis* of the subperiosteal tumors is usually easy, by attention to the characters just described, but in some instances is exceedingly difficult, especially the diagnosis from osteitis. The difficulty is now and then so great that it is only possible to make the distinction by frequent measurements, or by exploration. The continuous increase in circumference, which, in spite of rest, is proved by careful measurements at frequent intervals, is so significant of a malignant tumor that it may serve to turn the balance of opinion.

The *prognosis* of subperiosteal sarcoma is never favorable, and, for tumors of the femur and the humerus, is most unhappy. Even when the disease is limited to the lower third of the former bone, and when amputation can be performed so far above it that there is little fear of local recurrence, there is yet a strong probability that the patient may die within a few months of dissemination of the disease. And, although dissemination of tumors of the humerus is not so early or so absolute, the growth of the primary tumor along the bone is so rapid that amputation at the shoulder-joint at a very early period seldom suffices to avert local recurrence. Tumors of the bones of the forearm and leg are not so malignant. Their growth is not usually so rapid, nor is dissemination so frequently observed; amputation may easily be performed so high above them that local recurrence need not be apprehended. But these favorable conditions are not, by any means, invariably maintained, and a fatal issue from dissemination may occur within a year or eighteen months from the commencement of the disease. Subperiosteal tumors of the clavicle, the scapula, the pelvis, and the skull, are almost certainly fatal; those of the two last bones can scarcely ever be removed, those of the first two bones recur after a very short interval. The lymphatic glands are not affected by subperiosteal sarcomas, unless the tumor grows directly into a lymphatic gland, or in some similar fashion obtains access to the lymphatic system. Tumors of the more distant bones scarcely ever affect the glands; and tumors of the bones more near the trunk only affect them when they grow in close proximity to the glands. In the general dissemination of the disease, the bones, the distant lymphatic glands, the skin and subcutaneous tissue, and the lungs, are the parts most frequently attacked.

The only *treatment* on which the slightest confidence can be reposed is the early and free removal by amputation of all tumors which are so situated as to admit of it. The amputation must be performed far above the disease, to insure safety from recurrence, and when a point, as far above as the middle of the thigh is above a sarcoma of the upper portion of the tibia, is chosen, no fear need be entertained of return of the disease in the stump. The scapula and clavicle may be excised for subperiosteal tumors, but with a very faint hope of ultimate success. I have seen attempts made to remove tumors of the pelvis and the skull, but in neither instance did the attempt succeed. The manner in which the sarcomas of the calvaria grow through the bone into the interior of the skull, is a sufficient explanation of the failure of attempts to remove them, and the fact that they are usually multiple is a sufficient reason to deter a prudent surgeon from interfering with them.

Central Sarcomata of Bone.—The *clinical characters* of the central tumors are, the situation they affect (a circumstance of more importance than for the subperiosteal growths), their more globular shape, their more equal consistence where they are uncovered by the cortex of the bone, the occasional "egg-shell crackling" where a thin layer of bone still exists, and the occasional pulsation, observed especially in connection with tumors of the femur, the tibia, the skull, and the pelvis. They grow more slowly than the subperiosteal tumors, but much more quickly than the non-malignant tumors, and they are much less often the cause of inflammatory symptoms. They are usually the seat of pain, which may precede the appearance of the tumor by several weeks or months. The immunity of the neighboring joint from invasion is very remarkable, for the tumor often completely fills the articular end of the bone, and bulges out on every side; the cortex of the bone is destroyed, and the periosteum traversed, but the joint is still protected by a thin layer of cartilage, which will not yield to the advancing growth. A central tumor seldom occupies as much of the length of the affected bone as does a subperiosteal growth, and, as might be foreseen, ulceration is very infrequent. Multiplicity in different bones is more common for central than for subperiosteal tumors, unless, perhaps, in the calvaria, where it is the rule for subperiosteal tumors to be multiple.

The *diagnosis* of a central tumor is usually more difficult than that of a subperiosteal tumor. The growth is slower, the enlargement of the end of the bone more uniform. But attention to the following points will generally serve to establish the diagnosis. The tumor almost invariably continues to increase in size; the enlargement of the end of the bone, though often for a long time uniform, at length ceases to be so, and may affect one-half solely, or one much more than the other half. Inflammatory conditions which produce similar enlargements are, for the most part, diseases of earlier life than central tumors; they tend early to affect the neighboring joint, while central tumors leave the joint intact. In cases in which uncertainty cannot be otherwise relieved, an exploratory incision should be made.

The *prognosis* of central tumors is much more favorable than that of subperiosteal tumors. The local mischief is not as wide-spread; the glands in connection with the affected part are not diseased, except, perhaps, in connection with sarcomas of the tarsus and the sternum; dissemination is not as common an occurrence, nor does it take place as early. These favorable conditions render it justifiable to deal much more leniently with the disease in these cases than in those of subperiosteal growth.

Treatment.—Most sarcomas of the femur and the humerus, it is true, necessitate amputation, and the amputation should be performed high above the disease, to avert the possibility of local re-formation of the growth. But central sarcomas of the bones of the leg and forearm, unless the disease be very far advanced, and have destroyed a large fragment of the bone, may be removed by gouging or resection. It is scarcely necessary to advise that the operation, of whatever kind, should be thorough, and that every morsel of the disease should be removed, and the surface of the cavity in which it lay scraped, after the tumor has been gouged out. Central tumors of the clavicle and scapula can only be completely removed by taking away the bone in which they grow. Tumors of the skull, the sternum, and the pelvis are rarely amenable to operation. The generally favorable prognosis of central tumors rests chiefly on the modified malignancy of the tumors of the long bones, which constitute a very large majority of all central tumors.

SARCOMATA OF THE TESTIS.—The *testis* is liable to be attacked by round-celled, spindle-celled, and mixed-celled sarcomas, but specimens of mixed-celled tumors are not common. Many of the round-celled tumors belong to the variety lympho-sarcoma. The disease probably originates in almost all cases in the body of the testis; but whether as a single nodule which gradually enlarges until it occupies the entire organ, or as several separate nodules which speedily coalesce, or by a general affection of all the connective tissue, is not certain. The disease, in most instances, has affected the whole organ before an opportunity is afforded, by castration, for examination of the tumor. In rare instances the epididymis and body of the testis are simultaneously and proportionately enlarged, or the disease begins actually in the epididymis. But, generally, the epididymis becomes inseparably blended with the growing tumor. Sarcoma of the testis is not limited to certain periods of life; it has been observed in infants and in aged men, but it usually occurs in children under ten years old, or in men of from thirty to forty years.

When a sarcoma of the testis is cut open, the appearances are usually quite characteristic of malignant disease, but often only of malignant disease, not of the particular variety or class of tumor. Not only is it impossible in many instances to distinguish the particular subclass of sarcoma, but it is quite impossible to distinguish between sarcoma and carcinoma. The tumor is generally soft, pulpy, tolerably homogeneous, or traversed by fibrous bands, very juicy, and of dark-gray or fawn color. Here and there are tiny areas of caseous material. Certain conditions may, however, disclose the nature of the tumor. Cysts are most frequent in spindle-celled tumors, and cartilage occurs only in spindle-celled and mixed-celled tumors. In microscopic sections, seminiferous tubules may sometimes be discovered in the midst of the sarcoma-tissue, which separates them and slowly compasses their destruction. The cysts are formed by the dilatation of some of the tubules, and are lined with epithelium. Fatty and caseous degeneration are observed in most sarcomas, but usually only in small patches. The spindle-celled and mixed-celled tumors are frequently partly chondrified, and the organization may be so extensive that the tumor may appear to be wholly cartilaginous. This wholesale transformation of the tissues of a sarcoma, and the further fact that the disposition of the cartilage resembles that observed in simple cartilaginous tumors, has led to the error of including some of these growths in the class chondroma, and of speaking of them as malignant enchondromas on account of the course which they pursue. Their course resembles that of the spindle-celled sarcomas of the testis, the subclass to which they naturally belong; and there is not such a tumor as a malignant enchondroma of the testis. Pure cartilaginous tumors are invariably innocent.

Occasionally, but very rarely, bone is found in sarcomas of the testis, generally in the form of thin plates, or of a delicate skeleton, on which the soft structures might almost appear to have been built. Mucous tissue is more common than bone. The round-celled tumors are very rarely, if, indeed, ever, the seat of any organization-changes or of transformation, with the exception of slight fatty and caseous degeneration. Sarcomas of the testis do not often ulcerate, a circumstance which may probably be accounted for by the strength and thickness of the structures by which the organ is covered, and by the ease with which the growth extends along the cord towards the pelvis and abdomen. The tumor usually commences insidiously, but sometimes noticeably as the result of a blow or squeeze. The shape of the testis may be for a long time maintained, or the growth may be more globular or kidney-shaped. It is at first, and often throughout, quite firm or almost hard, owing to the tightness with which it is bound down by the tunica albuginea, for when the albuginea is incised the soft contents protrude or even escape. Usually, as the disease advances, the tumor becomes more prominent at certain points, and each prominence becomes softer, until at last there may be fluctuation. The tumor is thus unequal in consistence; but even over the softest spots there is no sign of inflammation, except in those rare instances in which the scrotum becomes adherent and gives way. At an early period the cord is thickened, and, with the gradual progress of the tumor, it becomes at length greatly enlarged. The lymphatic glands of the abdomen are affected by every kind of sarcoma, provided only that the disease is not cut short at an early period by operation, or by the patient's death. The glandular affection usually commences within a few months of the enlargement of the testis, but may be deferred to a much later period. In a few cases both testes are attacked simultaneously, or after a short interval, but only by round-celled sarcoma. Dissemination may take place in all forms of sarcoma, but, as in sarcoma of the bones, it is most widely spread and earliest in the case of the round-celled tumors. The subcutaneous tissue and the bones are selected particularly by the round-celled tumors, but all three forms met with in the testis attack the lungs.

The *diagnosis* of sarcoma of the testis will demand consideration in the article devoted to diseases of that organ, but attention may be here directed to one or two important points. The unequal consistence of the tumor, and, sometimes, its fluctuation without any sign of inflammation ; the fact that the body of the testis is affected ; and the absence of all history of syphilis and struma, taken in connection with the age of the patient, are the most valuable and reliable symptoms. The presence of fluid in the tunica vaginalis, which sometimes occurs in large quantity, may obscure the characters of the tumor, but the removal of the fluid allows an examination to be made. In very doubtful cases the tumor itself may be punctured. Bright blood flows freely through the canula from malignant tumors. The diagnosis between sarcoma and carcinoma cannot in most instances be made; but when both testes are affected, or when the patient is a child, the disease is certainly not carcinoma.

The *prognosis* of all sarcomas of the testis is grave: it is most grave for round-celled sarcoma, and for sarcoma in children. Children appear seldom to escape a fatal issue: in them the glands are early affected, and castration is rarely early enough performed. In adults, the course of the disease is not in all cases so rapid ; and the prognosis, therefore, is not quite so bad.

The only *treatment* on which the faintest reliance can be placed is that of castration, performed high up, and at as early a period as possible. If the cord be obviously diseased, the operation will be useless, for the disease will certainly recur locally. Affection of both testes does not of necessity preclude operation, but the chances of success are proportionately diminished. Even when the glands are already enlarged, and when no hope can be indulged of completely removing the disease, castration may yet be performed for the temporary relief of the patient.

SARCOMA OF THE TONSIL.—The *tonsil* is subject, apparently, only to one kind of sarcoma, the round-celled, or the variety lympho-sarcoma. (Plate XX. Fig. 20.) The entire tonsil enlarges and projects into the fauces. The disease usually attacks adult males between the ages of twenty and sixty years. On section, the tumor is generally soft, easily broken down, juicy, vascular and darker-colored than the normal tonsil. With the exception of slight fatty degeneration and mingling with fibrous tissue, or perhaps fibrification, the tumors are very free from secondary changes. The disease rarely affects more than one tonsil. The tumor commences insidiously, but grows rapidly, and in the course of a few weeks projects as a rounded mass as far as, or across, the middle line of the fauces. The mucous membrane covering it is often livid, and not infrequently ulcerated, but deep ulceration and sloughing of the tumor are rare events. The growth is prone to invade the adjacent structures, the palate, and the tongue. The cervical glands become enlarged, usually at a very early period ; in three months after the first appearance of the tumor, they are often already extensively diseased. The tumor of the tonsil may be felt deep down from the outside of the neck. As the disease advances, deglutition is seriously interfered with, articulation becomes indistinct, and stiffness of the throat and neck gives rise to great complaint. Death may occur within a few months of the outbreak of the disease, or may be delayed for about a year, but few patients survive more than twelve months. In the few instances in which a post mortem examination has been made, the liver has been once found to be affected, and the lungs once or twice. With the lungs, in one case, the walls of the intestine, the peritoneum, and the mesenteric glands, were also diseased.

The *diagnosis* of sarcoma of the tonsil is not very difficult. The enlargement of a single tonsil in an adult patient, is in itself a suspicious circumstance; and when to this are added the continuous and rapid growth of the tumor, the absence of signs of inflammation, and the globular shape and darker hue than natural, suspicion is exchanged for certainty. The *prognosis* is most unhappy. There is no malignant disease which appears to run so rapid and so smooth a course to death. Ulceration, suppuration, hemorrhage, impairment of deglutition, impeded respiration, and dissemination, combine to exhaust the patient's strength, and surgery offers scarcely a prospect of even temporary alleviation of his suffering.

Treatment.—The tonsil may be removed either from the mouth or through an opening in the neck, and, although both operations may appear fraught with excessive danger, they are very seldom fatal. The operation through the mouth may be performed with the *écraseur*, or with the actual or the galvanic-cautery: contrary to what might naturally be expected, the hemorrhage is seldom severe. The operation from the neck presents the advantage of the possibility of much more free removal of the primary disease, and of extirpation at the same time of one or more affected glands. In spite of the importance of the parts in the midst of which the incision must be carried, even this operation may be performed with comparative safety. Unfortunately, both operations are speedily followed, in almost every case, by recurrence; so that the short relief obtained is scarcely sufficient to compensate for the distress of the operation. In the only successful case with which I am acquainted, in which the tumor was removed through the mouth, I am sometimes tempted to wonder whether the disease was really a sarcoma.

Sarcomata of the Larynx.—The sarcomas of the *larynx* offer in many respects a striking contrast to those of the tonsil. The disease is far more dangerously situated, yet its progress is less rapid, and it is more amenable to treatment. It is difficult to comprehend why there should be so much difference in the disease of two parts so nearly neighbored; it may perhaps lie in the softer consistence and cellular structure of the tonsil, and in its close connection with the lymphatic glands. The structure of the parts of the larynx beneath the mucous covering is, for the most part, fibrous and muscular. In accordance, therefore, with the general rule that the structure of the parent tissue exercises a marked influence on the structure of its tumors, most of the sarcomas of the larynx are spindle-celled or fibre-celled. Round cells are often mingled with the spindle-cells, but a pure round-celled tumor is an exception. The disease may originate in the epiglottis, the ventricular bands (false cords), or the vocal cords. One case has been described by Morell Mackenzie, in which the tumor grew from the posterior aspect of the cricoid cartilage.[1] It attacks adults, rarely children, and is rather an affection of middle and advanced, than of younger adult life. Most of the cases occur in males; at least three times as many males as females are attacked, a difference possibly accounted for by the much coarser use to which the larynx is subjected in the male sex. The tumor does not usually grow very quickly, and does not usually grow very large. Large size seems almost precluded by the nature and situation of the parts affected. Many of the tumors which have been removed are thought to have existed months or even years before the operation. Yet they are very small. On the other hand, quick growth has been observed, and early operation has been called for by the dyspnœa occasioned by the tumor. Sarcomas of the larynx are more often outgrowths than circumscribed and separable tumors; sometimes they are quite smooth, more commonly papillary or coarsely warty, sometimes foul and deeply ulcerated, like an epithelioma. They have no tendency to undergo metamorphosis of structure, unless it be towards fibrous tissue, which is tolerably abundant in some of the tumors. The surface of the tumor is generally red, but may be yellow or gray when viewed with the laryngoscope. In its progress, the tumor tends to affect the neighboring structures, and may invade and perforate the cartilages of the larynx, may attack the tongue, the palate, or the pharynx, or may involve the upper portion of the gullet. The glands are practically never affected. Only once were they enlarged in eighteen cases of which I have collected notes, and in that case the primary disease had passed completely through the thyroid cartilage, and had thus been brought in close proximity to the affected glands. Nor does there appear any greater proneness to dissemination; not even in the lungs, which are singularly well situated to receive blood returning from the affected part, and fragments of the growth carried down by the inspired air.

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[1] Diseases of the Throat and Nose, vol. i. p. 350.

By reason of this immunity from glandular affection and dissemination, the *prognosis* of sarcoma of the larynx is not nearly as unfortunate as that of the disease last discussed. If left to itself, naturally it will prove fatal, either directly by obstructing the entrance of air through the glottis, or indirectly by inducing spasm of the glottis, or by favoring the course of an intercurrent pulmonary malady. In selecting an appropriate treatment, it is very necessary to be sure of the *diagnosis*, not merely from innocent tumors, but from carcinoma. Generally, the larger size and more rapid growth of the tumor, with its irregular shape and tendency to ulceration, are sufficient to distinguish it from an innocent tumor. But the diagnosis from carcinoma is so difficult when the surface is deeply ulcerated that, at an early period of the disease, it may be impossible to make it by observation with the laryngoscope. In such cases it is not only justifiable, but most advisable, to remove with the laryngeal forceps a fragment for examination. A very small portion is sufficient to enable a person even moderately skilful with the microscope, to make out whether the disease is sarcoma or squamous-celled carcinoma (epithelioma).

The *treatment* may be either palliative or curative. The palliative treatment consists chiefly in opening the trachea and soothing pain by blowing morphia powder down upon the surface of the tumor. The curative treatment, or removal of the disease, may be performed through the mouth or through the neck. When the disease is limited to the epiglottis, it may be removed by means of an *écraseur* through the mouth; and, although there is a great tendency to recurrence, and the operation may need to be repeated, the result may nevertheless be satisfactory. When the disease is more deeply seated, and especially when it has invaded the surrounding structures, and when there is, therefore, no prospect of removal by such simple measures, excision of the larynx may be undertaken, either partial or complete, and, with the larynx, may be removed all the adjacent parts which are affected. Thus, Dr. Caselli, of Reggio Emilia, cut out the larynx, with adjacent portions of the pharynx, palate, and base of the tongue, in a young woman 19 years of age. Twenty months afterwards the patient was well and free from recurrence. And Dr. Gerster, of New York, removed the right half of the larynx and hyoid bone, a portion of the pharynx, the right tonsil, and part of the base of the tongue, in a man of 50 years, who died of pleurisy a year subsequently, without a trace of return of the disease. These results of operation serve to prove that laryngeal sarcomas may be attacked with confidence, even when they are extensive and affect important structures around the larynx. The diagnosis between sarcoma and carcinoma, on which stress was just now laid, is important, because the result of similar operations practised for epithelioma, is so little successful that the question has been raised whether it is justifiable.

SARCOMATA OF THE ANTRUM.—Sarcomas of the *antrum* may be round-celled or spindle-celled, and one or two instances of mixed-celled tumors have been described, in which giant-cells were present. The round-celled tumors are rather more frequently met with than the spindle-celled, and, probably, the preponderance would be still greater were it not that ossifying fibromas have not infrequently been described as ossifying fibro-sarcomas, and have thus been classed among the spindle-celled sarcomas. In the structure of these ossifying fibromas, coarse fibres, which may be mistaken for the fibre-like cells of some spindle-celled tumors, are present in large numbers. But a careful study shows that they are fibres and not fibre-cells, and the course of the tumors is that of fibroma, not of sarcoma. The consideration of tumors of the antrum is rendered difficult by the impossibility, in the large majority of cases, of discovering the precise origin of the disease. It might be thought that it was enough to know that it occupied the antrum, but when the great difference in the properties of the central and sub-periosteal tumors of bone is remembered, it may easily be conceived that differences of origin of the sarcomas which grow into the antrum, may involve important differences in their properties. The account of these tumors has not, therefore, the same scientific value as the account of the tumors of which the point of departure can be clearly ascertained. Nevertheless, there are some features which they possess in common which are highly interesting.

Characters and Course.—These growths appear in some instances, especially in young subjects, to be caused by the irritation of a misplaced tooth which has been found, on removal of the tumor, imbedded or encysted in its substance. The disease is much more common in adults than in children, but is not uncommonly met with in young adults, about, or a little beyond, twenty years of age. From this period to quite old age it may frequently be observed. It appears rather more common in males than females. Most of the sarcomas of the antrum are soft and very vascular; they vary much in color and appearance, some being white and opaque like the typical medullary cancer, some gray, puffy, and blotched with blood, some brown or yellow-brown; they are not encapsuled, but may be contained within a shell of bone formed by the expanded antrum; they seldom contain cysts, although the antrum is peculiarly subject to cystic affections; they fill the entire cavity, expand and in time destroy the bone, and then affect the surrounding structures; they may be partly ossified, or calcified, or chondrified, but these changes, although they may occur in every part of the tumor, seldom transform large portions of its structure. Fibrous tissue occurs more abundantly than any other, so that some of the sarcomas are largely composed of fibrous tissue. By the growth of a sarcoma of the antrum a well recognized deformity of the jaw and face is speedily produced, for the tumor is usually very active, and the rapidity of its growth permits no doubt of its malignant nature. But, to rapid growth is frequently added implication of the skin of the face, with discharge from the nose and mouth. And, unless the disease be interfered with, the cheek may ulcerate and a fungous mass protrude.

The *diagnosis* between sarcoma and carcinoma of the antrum cannot, I think, in many instances, be made, but carcinoma does not generally attack persons as young as many of those who are the subjects of sarcoma. The diagnosis from carcinoma is not, however, as in the case of tumors of the larynx, very important, for in the antrum the course of the disease and the treatment applicable to it are the same in both diseases.

Prognosis.—The course of the disease is towards a fatal termination; it extends into the sinuses of the ethmoid and sphenoid bones; it ulcerates and discharges abundantly; but it does not usually become disseminated, nor does it affect the lymphatic glands. It is, therefore, in most instances a local malady, sometimes, indeed, very extensive, and not infrequently so diffused and so situated that it cannot entirely be removed. But, when it is of short duration and limited in extent—when, for example, it has not penetrated into the structures around the antrum—its strictly local character should be carefully borne in mind, and the treatment be devised on this assumption.

The only *treatment* to be recommended is complete removal of the upper jaw at the earliest possible period; and, if the disease has spread beyond the jaw, removal of the affected and suspicious tissues as widely as may be practicable. No consideration of sparing tissues or organs because of their importance, provided that they can be removed with safety, should seduce the operator into allowing tissues to remain which he may suppose to be affected even in the slightest degree. The prognosis of the result of operation would be much more favorable than it is, if the patients came under notice at an earlier period. But the first stages of the disease are often very insidious, and cause so little distress that its gravity is underrated.

SARCOMATA OF THE FOOT.—Several cases of sarcoma of the sole of the *foot* have come under my observation, and, as their progress up to a certain point has been very uniform, the disease seems worthy of notice here. The tumor begins in the skin or subcutaneous tissue of some part of the sole, usually near the middle of the forepart. At first it feels like a corn, and as it increases in size a sore may form over it, or a bleb, which bursts and fills again. If the tumor be dissected out, it is found to extend from the skin to the plantar fascia, and to be quite circumscribed, but not encapsuled. It may be tolerably firm, or soft and juicy; in either case it looks more like sarcoma than carcinoma. At the time of removal, when the tumor has existed for perhaps a year, it may be no larger than a walnut. The disease usually occurs in persons about the middle period of life; it appears to them a trivial matter, and even to the surgeon not of grave importance. But in the course of a few months an induration appears in close proximity to the scar, or several little nodules in the skin or subcutaneous tissue. And, about the same time, the femoral glands become enlarged; and, either then or later, tumors form in the skin and subcutaneous tissue of other regions of the body. By this time the disease is past all hope of treatment by operation, and usually the end is not far distant. In the only case of which I have seen a post-mortem examination, there was very extensive visceral disease in addition to the widely spread dissemination in the skin and subcutaneous tissue. The disease in this case was round-celled sarcoma, which is apparently the variety met with in most of these plantar tumors.

With the experience of so few cases, it is not possible to speak very strongly on the questions of *diagnosis* and of *treatment.* A definite tumor, however, in the sole of the foot of a person over forty years of age, of six months' or a year's duration, is probably a sarcoma. Incision into it will clearly expose its character. In view of the prognosis which the cases hitherto observed afford, it may well be asked, whether it would not be wiser to amputate at the ankle-joint than merely to remove the tumor.

It would be easy to multiply instances of sarcomas of organs and tissues, to show how the course and character, and, with them, the treatment of the disease, are influenced by the nature and situation of the part which is affected. But the instances which have been given suffice to prove this as clearly as is necessary, and neither time nor space will permit of more copious illustration. In the articles which treat of the affections of each organ and tissue, other examples will be found. Every example of the disease shows that it is absolutely essential, in addition to a general survey of sarcoma, to study the sarcomas of each organ and tissue separately, and that only thus can a complete knowledge of the whole subject be arrived at.

Endothelioma or Endothelial Tumor.

This is a cellular tumor derived from endothelium. The materials which are within our reach for a complete account of this disease are scanty and insufficient. Our knowledge of the anatomy even of undoubted endotheliomas is very imperfect, and the information which we possess of the disease, in all other situations than the endothelial surfaces, is so small that it is impossible to do justice to the subject. It is not improbable that constantly increasing knowledge of tumors will discover that many growths, which are now classed otherwise, must be placed among the endotheliomas. Varieties of the disease will be discovered; metamorphoses and combinations will be described; and endothelioma may be found to be as important and easily recognizable as carcinoma or sarcoma. It has already been mentioned that some authors derive the sarcomas, if not of all parts, yet certainly of some parts, from endothelium. If this be so, these tumors are endotheliomas, not sarcomas. I have given reasons for not accepting this view for all sarcomas, and for believing that these growths are more often derived from the fixed connective-tissue corpuscles. But I can quite believe that many of the atypical specimens of sarcoma of various parts will prove to be endotheliomas. Until this has been proved, however, it will be safer to regard as endotheliomas only those tumors which grow from endothelial surfaces, and which appear to be derived from the endothelium of these surfaces rather than from the membrane or tissue which underlies the cells. Such tumors have been observed on the serous membranes, especially the pleura; and I think many of the tumors of the inner surface of the dura mater and of the other membranes of the brain and spinal cord—such, for instance, as the *nest-celled sarcomas*, and some, if not all, of the *psammomas*—may be fairly included in this class.

Gowers has described[1] three cases, in each of which the tumor sprang from the inner surface of the dura mater. Each was globular in form, and about the size of a small orange, with a nodular surface. Their consistence varied; the older portions, near the origin at the dura mater, were very firm, but the more recent parts were much softer. In one specimen the whole tumor was soft, not firmer than brain-tissue. Each specimen was grayish in color. Each was composed chiefly of spindle-cells, in the midst of which were nests of concentric cells, resembling those found in squamous-celled carcinoma; one of these nests had become calcified in the centre. Each of the tumors had pressed the brain-substance on one side, but had not invaded it. No further particulars are given of the cases, for the paper deals chiefly with the development of the spindle-cells, which appeared to be by vacuolation or endogenous cell-formation in the interior of round, nucleated cells.

I do not think that all the psammomas can at present be reckoned to be of endothelial origin, for some of them are composed almost wholly of fibrous tissue, and therefore more probably originate in the connective-tissue constituents of the membranes. But some of the psammomas are composed chiefly of cells resembling epithelial cells, and the sand bodies in them are apparently calcified epithelial, or rather endothelial, globes.

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[1] Medico-Chirurgical Transactions, vol. lix. p. 217. 1876.

It is possible that certain rare conditions of the tunica vaginalis belong also to the category of endotheliomata. Thus a case is described by Dr. Cauchois,[1] of an affection of the testis and the tunica vaginalis, in which the latter became the seat of fungosities adherent to its inner surface. These were examined by MM. Ranvier and Thaon, who found that they contained amyloid corpuscles, similar to those occurring in glioma and fine retiform tissue. M. Ranvier termed the disease "sarcôme névroglique," on account of the resemblance of its structure to that of the gliomas.

The cases respecting the nature of which there appears to be the least uncertainty, are the tumors of the larger serous membranes, the pleura and the peritoneum. Schultz[2] and Eppinger[3] have each described cases in which these membranes were much thickened and stiff from cancerous transformation. The general characters of the disease, and even the microscopic characters up to a certain point, were those of a carcinomatous disease; but, although the cells were epithelioid, and were apparently arranged in alveoli, there were circumstances which pointed strongly to the belief that they were derived from the endothelium of the membrane, and that the alveoli were sections of communicating tubes filled with cells. By the endothelium of the membrane must be understood, not merely the cellular covering of the membrane, but the germinating cells around the stomata, and the endothelium of the lymphatic vessels which are entered from the stomata. These tumors were malignant—fatal not merely from their situation, but by producing metastases. Both the pleura and the peritoneum were affected in one case, and secondary affection was observed of the lung and the liver, the muscles of the back, and the axillary glands. In another case, in which both pleura and peritoneum were involved, the primary disease was presumably of the peritoneum, and the mesenteric and retro-peritoneal glands were also secondarily affected. Klebs has described[4] a bloodvessel-endothelioma of the pia mater, but the evidence does not seem to me conclusive that the disease really owned the origin attributed to it by the author. And Block[5] has recounted a case of pigmented endothelioma of the liver with secondary nodules in the heart and kidney. Amongst others, the view of Köster must not be forgotten, that carcinoma of the skin is of endothelial origin.[6] If this view be accepted, then there may be added to the many sarcomas which are not improbably of endothelial origin, a large section of the carcinomas, and the class endothelioma will swallow up a large part of the sarcomas and carcinomas.

The *symptoms* of endotheliomas of the serous membranes are so blended with the symptoms of inflammation and of visceral disease, that even the fact that the disease is a tumor formation may be difficult or impossible to ascertain. The symptoms of endotheliomas of the more external parts are, thus far, only known to resemble the symptoms of other malignant diseases of those parts. Of the *diagnosis*, therefore, nothing can be definitely stated. The *prognosis* seems to be in most instances bad. The *treatment* depends, naturally to a large extent, on the character and situation of the part affected. In the large majority of cases no hope can be entertained of cure, or even of relief, by operation; for, even should these tumors of the serous membranes be removed, there appears every reason to believe that they would speedily return.

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[1] Bull. de la Soc. Anat., 3e sér. t. vii. p. 289. 1872.

[2] Archiv der Heilkunde, Bd. xvii. S. 1. 1875.

[3] Prag. med. Wochenschrift. Bd. i. No. 4 und 5. 1876.

[4] Prag. med. Wochenschrift. Bd. i. No. 6. 1876.

[5] Archiv der Heilkunde, Bd. xvi. S. 412.

[6] Die Entwickelung der Carcinome. Wurzburg, 1869.

PAPILLOMA; PAPILLARY OR WARTY TUMOR.

The papilloma is a tumor composed of papillæ (Plate XVIII., Fig. 5), whose structure comprises a basis or central stem of connective tissue, containing usually a vessel or vessels, and a covering of epithelium.

Two varieties of papillary tumor are commonly described, the hard and the soft. The former is represented by horns, and warts, and warty growths; the latter by villous tumors, such as are met with in the bladder. Both varieties are probably produced, in the majority of cases, by chronic inflammation, or by various forms of irritation. Thus, the work of certain occupations leads to the formation of warts—chimney-sweepers and workers in tar are notably subject to them. The irritation of long-continued discharges and the collection of dirt cause the formation of warts upon the penis. Chronic inflammations of the larynx are productive of warty excrescences, and sometimes of warty growths of grave importance.

CHARACTERS AND COURSE.—Papillomas may occur in many different situations on the skin, any part of which they may attack; but they are very frequent on the hands and face, as warts; about the genitals, the scrotum, and the anus, as warts and condylomata; on the lips, especially the lower, again as warts. They occur on the mucous membranes (1) of the respiratory tract, where they attack the vocal cords and, more rarely, the interior of the nose, the epiglottis, and the trachea; (2) of the digestive tract, where the tongue, œsophagus, stomach, and intestines (particularly the colon and the rectum) are affected; (3) of the genito-urinary tract, where they affect, in women, the vagina and the vulva, in men the penis, and in both sexes the bladder. They grow, also, on serous membranes, where they are covered with endothelium, not with epithelium. And they are developed, sometimes, in the interior of ducts and tubes—in the galactophorous ducts, for example—where, by the obstruction which they produce, they occasionally play an important part in the development of cysts.

They may occur at any age, but are more common in young persons than in persons even at the middle period of life. They are sometimes congenital; but the period of life at which they grow depends largely upon the part which is affected, and upon the cause of the disease.

The manner of their development on surfaces which are naturally papillary, is merely by hypertrophy of the natural papillæ, or by outgrowth of one or more papillæ and the formation of compound papillæ on the outgrowth. The development on surfaces which are not naturally papillary, is probably by the formation of small protrusions of the sub-epithelial connective tissue, into each of which a vessel is projected.

The appearance of a papilloma generally clearly indicates its nature, for its papillary structure is usually very evident. Yet, papillomas differ exceedingly in shape; some of the most typical warty growths are sessile and low, and almost tubercular; others are pedunculated, prominent, and pointed; the true horns or horny growths are not papillary on the surface, but project from the skin from which they grow to the extent often of an inch or more, sometimes even of several inches, when they are usually curled or twisted; the papillomas of the bladder comprise the most admirable specimens of villous growth, and can be floated out in water, like fragments of a delicate, branching sea-weed. Most of the papillomas of the skin are dry and hard; those of the lips and penis are often moist and discharge freely. The papillomas seldom attain a large size; indeed, the largest specimens are found in the great cauliflower condylomata about the vulva and the anus, and the largest of these is rarely as large as the closed fist of a child.

MICROSCOPIC APPEARANCES.—The microscopic characters of the disease have been indicated in the definition. The connective tissue which forms the basis of each papilla, and of the whole tumor, when, as in some instances, there is a central mass, is usually simple fibrous tissue; but it may be rather mucous than fibrous, and in either case may vary much in quantity, sometimes forming only a slender, central stalk, sometimes a mass of considerable thickness. In the smallest papillæ there is often only a single capillary loop; it is very unusual to find a papilla which does not contain a bloodvessel. The larger papillæ may contain an artery and vein with the proper capillary network. Occasionally a kind of cavernous system exists in the interior of the papillæ, composed of large, thin-walled cavities filled with blood, and communicating with the afferent and efferent vessels. The formation of these cavities probably resembles the formation of similar cavities in the cavernous angeiomas; that is, they are dilatations of the bloodvessels, and not spaces of new formation which have acquired a communication with the vessels. The epithelial covering of the papillæ is squamous or columnar, according to the character of the epithelium of the part affected. It may form only a single layer, or may consist of many layers; it may resemble the horny layer of the epidermis; and in some specimens exhibits differences in the characters of its layers—the most internal being imbricated or radiating; the middle layer large, well-formed, and spheroidal; the external flattened, thin, and scaly.

METAMORPHOSES, ETC.—Some of the warty growths are pigmented, so much so, indeed, that they are quite black. These pigmented growths are not infrequently congenital, and form the dark and warty moles noted at birth, and sometimes associated with large areas covered with hair. It is these pigmented moles which are prone in later life to grow, and after removal to grow again. Apparently they undergo a complete transformation of their structure, for investigation shows that, in such cases, the basis of the tumor and of the papilla is a sarcomatous tissue. This is not the only transformation to which papillomas are subject; they become even more commonly carcinomatous. The liability to cancerous transformation is so thoroughly recognized, that it is considered not only possible, but almost probable, that an irritated warty growth of the lower lip or scrotum will become an epithelioma. Further, it must be borne in mind that epitheliomas and superficial sarcomas sometimes present a warty aspect, which may be perfectly papillary, so that a combination of these diseases with papilloma may be described. The term combination is, however, scarcely justified, for the papillary surface is but a variety of the outward form of certain sarcomas and carcinomas, and the papillary structure produces not the slightest influence on the nature of the disease.

Papillomas are subject to inflammation, and not uncommonly are ulcerated, or at least excoriated. Under these circumstances they discharge, and are liable to bleed. Hemorrhage is, in truth, a prominent symptom of the papillomas of certain parts, even when no ulceration is present. Thus, the villous tumors of the bladder generally bleed, sometimes profusely, so that the chief danger from them is from loss of blood. Their extreme delicacy of structure, their vascularity, and the pressure to which they are at frequent intervals subjected, may account for the tendency to hemorrhage. A papilloma may slough completely off, or, being loosely attached, may be knocked off, and thus a cure result.

Symptoms.—The clinical characters of most papillomas have been described in the account of the macroscopic characters of the disease. But, in addition to the outward form and other features, there are certain points to which attention should be directed. It must be always borne in mind, that, however much a papilloma may deface the part from which it grows, it is, after all, only a superficial affection, springing from the surface, and not affecting the subjacent structures; and that its tendency is not to destroy its site, but merely to disfigure it. Even when it ulcerates or sloughs, the destruction is limited to the tumor, and rarely or never penetrates to the parts beneath. From a knowledge of these characters another important character may be inferred, namely, the absence of induration of the part from which the tumor grows. If there be induration, it is due to some other cause, such as inflammation, and is not dependent on the presence of tumor growth. Papillomas are often multiple, in proof of which the warts on the hands and penis may be mentioned, and the condylomata. Of course, the symptoms of papillomas of parts in which the tumor cannot easily be observed, are often very obscure, and to enter on a long description of the symptoms and diagnosis of papillomas of the bladder, the larynx, the nose, and other similarly situated parts, would be foreign to the intention of this article.

Diagnosis.—In most instances the diagnosis of a papilloma lies on the surface, and presents absolutely no difficulty. The appearance of the tumor itself is conclusive. But occasionally there is a difficulty in deciding between a papilloma and a sarcoma or epithelioma. In the first case, the much more rapid growth of the sarcoma, the affection of the deeper structures of the skin and subcutaneous tissue, and consequent induration, and the evident fact that here is a tumor of which the surface only is papillary, lead to a correct decision. In the second case, the diagnosis is often much more difficult, as, for example, between a papilloma and epithelioma of the lip, or of the scrotum. In both these instances, the induration at the base of the warty growth, in epithelioma, and the ulceration, which, when present, extends into the substance of the lip, with the more rapid progress of the tumor, are the points on which the diagnosis chiefly must depend. But where a papilloma is being gradually transformed into an epithelioma, the characters of the two diseases may be confusedly blended.

Prognosis.—The prognosis of papilloma is very hopeful. In fact, as far as the tumor is itself concerned, the only dangers which need be apprehended from it are hemorrhage, and the possibility, not very remote under what may be termed favorable conditions, that the tumor may become an epithelioma. As long as it remains a papilloma, it exhibits no disposition to glandular affection or dissemination. It may recur, certainly, after a removal, but the recurrence is due, not to any specific vices which are in the tumor, but to the difficulty of dealing with it completely in certain situations. The prognosis of papillomas of the bladder and the larynx is grave on account of the site of the disease, not on account of the nature of the tumor.

Treatment.—The treatment varies widely to suit the requirements of the case. The common dry warts on the hands may be treated by touching them with sulphuric acid. A single application in most instances suffices for the cure. Each wart turns yellow, shrinks, and, in a few days, drops off, leaving behind a slight depression where it stood, which soon fills up and leaves no appreciable scar. The treatment is quite painless. The same method is applicable to warts upon the penis and vulva, but they are more often snipped off with scissors, and the bleeding surface touched with chromic acid or solid nitrate of silver—a painful method, but effectual. Horns are removed with the knife, and the vessels, which are not large or numerous, are tied. Condylomata, when large, are removed with the knife or *écraseur*, and the wounds are often touched with solid nitrate of silver, or some other strong caustic, to guard against recurrence. Papillomas of the tongue may be removed with the galvano-cautery, which may also be employed for condylomata. The warty tumors of the larynx are generally removed with the galvano-cautery or the forceps: the number and the situation of the growths, not only upon, but beneath the vocal cords, make it most tedious and difficult completely to remove the compound papillomas. They recur again and again, until the patience of both operator and patient are well nigh exhausted. The treatment of villous tumors of the bladder, the rectum, and similar parts, cannot be considered here.

ADENOMA OR GLANDULAR TUMOR.

The adenoma is a tumor resembling in its structure a secreting gland. Two varieties of adenoma may be described, the first resembling the structure of the racemose glands (Plate XXI., Fig. 25), the mammary gland for instance, the second resembling the structure of the long tubular glands, such as the crypts of Lieberkühn. (Plate XVIII. Fig. 4.)

Typical specimens of adenoma of either variety, uncombined with other tissues, are much more rare than is commonly taught. On the one hand, adenomas are confounded with carcinomas in which the glandular character and origin of the disease are more than usually stamped, and, on the other hand, many tumors are termed adenomas which are largely composed of fibrous or other connective tissues, and in which gland-tissue, though tolerably abundant, plays only a subordinate part. I have myself always limited the use of the word adenoma to tumors which are almost entirely composed of glandular structures, and which contain only as much connective tissue as is required to knit the acini, or tubes, and ducts, into a compact mass, and to those tumors which bear not only a general resemblance to glandular tissue, but which are composed of acini, or tubes, provided for the most part with a lumen, and surrounded by a membrana propria.

The *racemose adenomas* are found chiefly in the mammary gland and the parotid; less often in the skin, the tongue, and the liver. The *tubular adenomas* grow in the prostate, and in the mucous membranes of the mouth, rectum, nose, and uterus. The adenomas of the thyroid body resemble the racemose, much more closely than they do the tubular glands. In almost every instance, adenomas originate in connection with previously existing glandular structures, but it is thought that they may be produced by the epithelium covering the skin and mucous membrane. The method of their formation in a gland may be studied in the breast, where it resembles, in many respects, the natural development of the organ.

The epithelium of the gland proliferates, and solid cylinders of cells are projected into the surrounding connective tissue. From these cylinders secondary processes are put forth, and, being formed around the termination of the cylinders, the general disposition is that of a terminal duct and acini, or tubelets, which become perfect by the hollowing in them, at a later period, of a narrow lumen. It is difficult to be sure that the connective tissues do not take any active part in the development of the new gland-tissue, or to decide what share the epithelium and the connective tissues take respectively in the new formation; but the epithelium seems certainly to be the chief, even if it be not indeed the sole, agent. The growth of the tumor is effected in the same fashion, by the continued new formation of gland-tissue.

Characters and Course of Adenomata.—Some of the new formations of gland-tissue are congenital. The dermoid tumors contain excellent examples of gland-tissues, especially of sebaceous and sudoriparous glands. It is probable, too, that most, if not all, of the alimentary glands are congenital. Unless they are congenital, adenomas are almost invariably developed during adult age. Thus, the adenomas of the breast are found chiefly in women from twenty to thirty years of age; the adenomas of the salivary glands in young or middle-aged adults; those of the nose, the tongue, and the skin, at a corresponding period of life. The adenomas of the rectum are among the very few glandular tumors which are found, not very rarely, in young subjects.

Most of the adenomas are small, and few of them attain a very large size. When it is remembered that the polypi of the nose, uterus, and rectum are among the glandular tumors of those parts, the truth will at once be recognized that they rarely form large tumors. The true adenomas of the breast are among the smallest tumors which grow there. The chronic enlargements of the prostate which are adenomatous are very seldom large. The actual growth of all these tumors is, too, very slow, so that to attain even their small size may occupy several years.

Appearance after Removal.—The adenomas of the breast, the salivary glands, the thyroid, and some of those of the prostate, are circumscribed, lobulated tumors, inclosed in a firm, fibrous capsule. Those of the breast are often united to the gland by a slender cord. On section, all these tumors exhibit a compact structure, very much resembling the appearance of an active gland, a portion of the pancreas, for example. The compactness of the section is often broken by the presence of small cysts which are not unusual in these growths. The tumors of the skin and tongue are, in the same way, generally circumscribed and inclosed in capsules. A singular exception to this rule occurs in the disease which goes by the name of elephantiasis of the nose, and which consists in an irregular and most disfiguring enlargement of that part. Most of the enlargement is due to a great increase in new formation of sebaceous glands, but the disease is a continuous outgrowth, not a distinct and separate tumor. The adenomas of the interior of the nose, the uterus, and the rectum, however, are almost invariably polypi, and differ very little in appearance, if at all, from polypi of the same regions which are only partly formed of glandular structures, or which contain no glands. They are firmer than the mucous polypi, but, like them, are covered by mucous membrane.

The *microscopic structure* of the adenomas depends, naturally, upon the variety of the disease. The racemose adenomas consist of a large number of single cavities or acini, of round or slightly elongated shape, each inclosed in a membrana propria and lined with epithelium. The membrana propria consists, in whole or part, of a layer of endothelial cells; the epithelium, of one or several layers of spheroidal, or cubical, or columnar cells. Most of the acini are furnished with a small, central lumen. Sometimes they appear to have no definite arrangement, but usually they are disposed in lobules, or clustered around the end of a small duct. Several small ducts, with acini placed thus around their terminations, may join to form a larger duct, as in the normal gland. But at this point the resemblance ceases, for no main ducts exist. When first these glandular structures were developed they were, as may be judged from the description of the development, in connection with the normal glandular apparatus, and therefore with the gland-ducts. But the connection after a time was severed, although traces of it may be discovered in the slender cord which attaches some of these tumors to the gland from which they grow, and which contains an obliterated duct. All the glandular structures of which the tumor consists, are bound together by a small quantity of fibrous connective tissue, in which run the vessels, which are not very large or numerous. The tubular glandular tumors, of which excellent specimens may be found in polypi of the rectum, consist of long tubes, each having a membrana propria and a single layer of regularly arranged columnar epithelium, inclosing a narrow central lumen. The tubes are often branched, and their disposition is not as regular as in the normal mucous membrane. (Plate XVIII. Fig. 4.) Whether they all open on the surface of the tumor, I am not sure, but I think it probable that many of them are exceedingly long, and strangely bent and twisted, and that their communication with the surface is by a very devious and indirect route. These tumors usually contain a larger quantity of fibrous connective tissue than the most typical racemose adenomas.

Metamorphoses and Combinations.—In all, or almost all, these glandular tumors, even when the structure conforms most closely to the structure of the normal glands, there is noticeable one great defect: no preparation is made for the reception or bestowal of secretion which may be produced by the glandular apparatus. Fortunately, in the majority of the adenomas, however perfect may be the existing apparatus, the glandular function is not called into play, and the amount of secretion is not large enough to produce any inconvenience. But in some of the glandular tumors of the breast, the salivary glands, and other parts, under some stimulus of uncertain character, fluid is secreted, not necessarily of the same nature as that which the gland normally secretes, but sometimes very abundantly. The inevitable result of this effusion into cavities from which no outlet, or only an inefficient outlet, exists, is to dilate the cavities; and in this manner are formed the cysts which are found in glandular tumors, especially in the racemose tumors, and more especially in those tumors in which the glandular tissue is largely combined with fibrous and other connective tissues. In these latter growths, the most singular appearances are produced by the tendency to the formation of cysts on the one hand, and the tendency to increase of the solid structures on the other hand. The two events occur simultaneously, or nearly so. The fibrous or mucous tissues immediately around the newly formed or primary cysts, growing, project into the interior of the cysts, sometimes as large spheroidal masses, often as polypoid excrescences. The cysts, therefore, are no sooner formed than they are partly filled by ingrowths of the surrounding solid structures, covered, since they thrust the lining of the cyst before them, with epithelium in one or several layers. The largest cysts are often by this means subdivided into several cavities, which communicate more or less freely around and between the intracystic growths. If the effusion which led to cystic dilatation be arrested, and the solid tissues still continue growing, the cyst may be completely filled by intracystic growth. Nay, more, the intracystic growth may destroy and perforate the wall of the cyst, and, if the latter lie immediately underneath the skin, this gives way, and the intracystic growth protrudes as a fungous mass. Thus are produced some of the most characteristic of the cystic tumors of the breast—adenomas only in so far that they contain often a large quantity of glandular structure, and that the glandular structure exercises a marked influence on the general appearance of the tumors—but connective-tissue tumors in reality, since the capabilities of the tumors depend on the character of the connective tissue which they contain.

In the breast, combinations of gland-tissue with fibrous tissue, mucous-tissue, and sarcoma-tissue, are common. All these tissues may coexist in the same tumor, and with them, in very rare instances, cartilage has been observed. Such a tumor I have lately seen in the possession of Mr. Bowlby, who exhibited it to the Pathological Society last year.[1] It was taken from the breast of a woman 42 years old, had been growing 12 months, and was about as large as an orange. It contained gland-structures, some of which had been dilated into cysts, fibrous and sarcomatous tissues, and small nodules of hyaline and fibrous cartilage. Nor was this the sum of all the tissues which composed this extraordinary growth, for the cartilage had in some places undergone mucous and even calcareous transformation. In the salivary glands, combinations of cartilage with gland-tissue are not infrequent, and mucous and fibrous tissues commonly coexist with glandular structures. In the polypoid glandular tumors, the most frequent combinations are of fibrous and mucous tissue with the glands; and in the prostate and the uterus, gland-tissue and muscle-tissue are combined.

The cells of adenomas are subject to fatty degeneration, but the effect of this upon the tumor is unimportant. Far less infrequent, but of infinitely greater importance, is the transformation of an adenoma into a carcinoma. The steps by which this is effected are probably precisely the same as those by which a carcinoma is developed from the normal gland. But this transformation of adenoma is probably very unusual, although it appears very simple and natural, and although sometimes it is difficult to distinguish, in microscopic specimens, whether a tumor is in truth an adenoma or a carcinoma. The difference in the general characters of the two diseases is, however, very decided, and it is a rare event to observe a tumor which bears the clinical characters of adenoma, gradually assume those of carcinoma.

Adenomas are not subject to any special maladies. Even the ulceration which has been described is associated rather with the connective-tissue elements than with the glandular structures of the combination-tumors.

Symptoms and Diagnosis.—The clinical characters of adenomas are those of fibromas, or of combination-tumors of the same parts. Thus it is impossible to say with certainty before the removal of a tumor which presents the symptoms of a "chronic mammary tumor," of Sir Astley Cooper, whether it will consist wholly or chiefly of gland-tissue, or whether it will be composed almost solely of fibrous tissue, with a little fat and gland-tissue. The same mobility, the same nodular surface, the same hardness, the same slowness of growth, are characteristic of the tumor in either case. Multiplicity is not more common in one disease than in the other. Under these conditions the *diagnosis* of a pure glandular tumor is scarcely possible. It is therefore a happy circumstance that it is unimportant. For, as the characters of the adenomas resemble those of the fibrous, or of the combined glandular and fibrous tumors, so is the course of the two diseases similar. An adenoma is a quite innocent tumor, neither infiltrating the surrounding tissues nor affecting the lymphatic glands or other parts.

Treatment.—The treatment in most instances is removal, but the general rule is subject to modification for the tumors of certain regions. It applies generally to adenomas of the salivary glands, the breast, the skin, and the mucous membranes, when the tumors can be reached. In those cases in which the tumor is completely encapsuled, it suffices to remove it with its capsule; it is not needful or desirable to interfere with the surrounding tissues. In those cases in which the tumor is a polypus, it is necessary to remove it by cutting through its stalk, and the stalk must be destroyed to prevent recurrence of the growth. The steps of the operation do not differ, in either instance, from those which are customary in the removal of other innocent tumors of the same parts.

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[1] Transactions of the Pathological Society, vol. xxxiii. p. 306. London, 1882.

CARCINOMA.[1]

A carcinoma is a tumor of *epithelial origin*, possessing generally an alveolar structure. The cells are seldom separated by a visible intercellular substance. The vessels run in the walls of the alveoli, not between the cells, and the cells increase in number, chiefly by endogenous formation.

In treating of the carcinomas, a similar course will be pursued to that followed in describing the sarcomas. First, a general account of the disease will be given; next, a short account of each of the chief subclasses; third, illustrations of the manner in which different parts of the body are affected by carcinoma.

There are three subclasses of carcinoma: the spheroidal-celled or glandular-celled, the squamous-celled, and the columnar-celled or cylindrical-celled.

SPHEROIDAL-CELLED OR GLANDULAR-CELLED CARCINOMAS are those which are derived from the spheroidal or glandular epithelium of the racemose glands, the mammary gland, the liver, etc. The alveolar structure is generally well expressed, and the cells resemble those of spheroidal epithelium. (Plate XIX. Figs. 15 and 16.) The spheroidal-celled tumors include all those carcinomas which are commonly called hard (scirrhous, withering, tubular, fibrous) and soft (medullary, encephaloid, multicellular, acinous). The chief difference between the hard and soft carcinomas consists in the much greater quantity of fibrous tissue which the hard contain, and the much larger number of cells of which the soft are composed; but there does not appear to be any essential difference between them.

SQUAMOUS-CELLED CARCINOMAS are developed from squamous epithelium. (Plate XX. Figs. 17 and 18.) They include all the squamous epitheliomas; indeed, in English-speaking countries, epithelioma and squamous-celled carcinoma are practically convertible terms, provided that the term epithelioma be not extended to the cylindrical-celled carcinomas. The cells of squamous-celled carcinoma are usually easily recognized by their resemblance to those of the epidermis of the tongue, lip, and other parts. Their borders are often fringed or jagged, and they vary much in size and shape. Instead of a single nucleus, many of them contain two or three nuclei. Yet their general large size, flattened shape, and decided characters, serve to distinguish them from the cells of other tumors. The alveolar structure of epithelioma is not well marked; often, indeed, it cannot be said to exist. The connection of the disease with the epithelium of the surface is generally demonstrable. And in the masses or columns of cells which dip down from the superficial into the deeper parts, are almost always found the cell-nests or epidermic globes which are justly held to be so characteristic of the disease. These bodies are composed of flattened, scale-like cells, surrounding, in a few or many layers, one or more central cells. They are not, however, confined to epithelioma or even to morbid tissues, for they may be discovered in the normal skin and

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[[1] It will be observed that the term "cancer" is avoided, as having a *clinical* rather than a *pathological* signification.]

tongue; but they occur much more abundantly in epithelioma, and usually attain a larger size than under other circumstances.

CYLINDRICAL-CELLED OR COLUMNAR-CELLED CARCINOMAS are derived from the columnar epithelium covering surfaces, or lining glands or tubes. (Plate XX. Fig. 19.) Those of them which grow more slowly present a structure closely resembling that of the tubular crypts or glands; but those which grow more quickly exhibit a confused appearance of irregularly shaped cavities or spaces, lined with blurred and ill-formed epithelium. Although there is often an alveolar structure, the alveoli are usually lined, not filled, with epithelium. These tumors have been generally classed with the squamous-celled carcinomas, as a variety of epithelioma, but they bear no closer relation to the squamous-celled than to the spheroidal-celled carcinomas.

Several varieties of the subclasses of carcinoma are observed. The most important are the following:—

Colloid carcinoma, which has usually been described as one of the primary subclasses, but which appears to be a modified form of the spheroidal-celled carcinoma. The alveolar structure is very strongly expressed, but the alveoli contain usually, in addition to cells or groups of cells, a quantity of clear, colloid material, sometimes marked with faint lines or dots parallel with the walls of the alveoli. (Plate XXI. Fig. 26.) Drops of the same colloid material may sometimes be detected in the interior of the cells, whence the theory that this material is produced by a transformation of, or deposit in, the substance of the cells. Colloid carcinoma is known also by the names of gelatiniform cancer and alveolar cancer. It is probable that sarcomas sometimes undergo a colloid change.

Melanotic Carcinoma.—Although pigmentation is not as common in carcinoma as in sarcoma, melanotic carcinomas are occasionally observed. The pigment is deposited either in the cells or in the fibrous stroma.

Villous carcinoma may be mentioned, merely to point out how very rarely carcinoma exhibits a villous or dendritic form of growth; some examples of squamous-celled and columnar-celled carcinoma present a papillary surface, but most of the true villous growths are papillomas or sarcomas.

The reasons for the foregoing classification of the carcinomas have been set forth on a preceding page, and need not be repeated here.

LOCALITIES OF CARCINOMATA.—Carcinomas may grow primarily from any epithelial structure. They occur in the skin and mucous membranes, the secreting glands and their ducts, the eye and the lung; but they exhibit a great preference for certain parts of the skin and membranes, and for certain glands. Thus, they grow where the skin joins the mucous membrane at the entrance of the mouth, the anus, the vulva, and the glans penis; they affect the commencement of the alimentary canal, the tongue and the œsophagus, and the termination, the rectum, more often than the intervening portions. They attack the narrower or constricted portions of canals or tubes more frequently than the wider parts—the cardiac and pyloric orifices of the stomach, for example, the glottis, and the mouth and neck of the uterus. The preference for these parts of the skin and mucous surfaces is one of the arguments which Virchow has employed in favor of the theory that tumors, especially carcinomas, are produced by frequent injuries or irritation. And, certainly, very strong evidence can be adduced to support this view. The irritation of the lower lip by an ill-finished pipe, the irritation of the tongue by rough and carious teeth, the irritation of the penis by the collection of dirt and discharge beneath a tight foreskin, the irritation, or injury, of the anus by the passage of hard and ill-digested motions, may all be looked upon as possible, if not probable, causes of carcinoma. The carcinomas which occur on other parts of the skin may often be traced to a similar cause. For instance, those of the scrotum to the irritation of soot, those of the face to the scratching or tearing off of previously existing warts. Among the glands for which carcinoma has the greatest liking, the foremost place is taken by the female breast; then, but separated by a long interval, the testis, the pancreas, the parotid, the liver, and the kidneys. The thyroid and the supra-renal capsules are also selected from among the ductless glands. The reasons for the frequency with which the female breast is attacked, are thought to be the injuries to which it is exposed, and the great changes which it undergoes in development and in decline, in evolution and in involution. Some of the tumors of the skin, and many of those of the mucous membranes, are really tumors of glandular origin, the former originating in the sudoriparous and sebaceous glands, the latter in the crypts or mucous follicles.

The causes which have been mentioned are not so potent as to account for all the peculiarities which are observed in the origin of carcinoma. Why, for instance, should the disease affect the lower lip so much more frequently than the upper? Why are some glands scarcely ever affected, while other glands resembling them in structure and in function are comparatively frequently attacked? Why is carcinoma almost unknown during infancy and childhood, so rare during adolescence, so common after the middle period of life? The answer to the first question is sought in the greater irritation to which the lower lip is habitually exposed. The answer to the second question is scarcely attempted. The third question is thought to be answered by saying that the epithelium is more active during later life, or that it is subject to irritations which are unknown in earlier life. The insufficiency of these and similar answers is evident. The epithelium of many parts is as active in the young as in the old; the epithelium of the breast and testis can scarcely be supposed to be degenerate in women of thirty-five, or men of thirty, in whom carcinoma is not uncommon; the anus and the rectum are subject to precisely similar irritation in early and in later life. Even if the disease be due to the introduction of a parasite (micro-organism), it is not easy to understand why this should only gain access to the epithelium, or only produce its disastrous results, after a certain period of life.

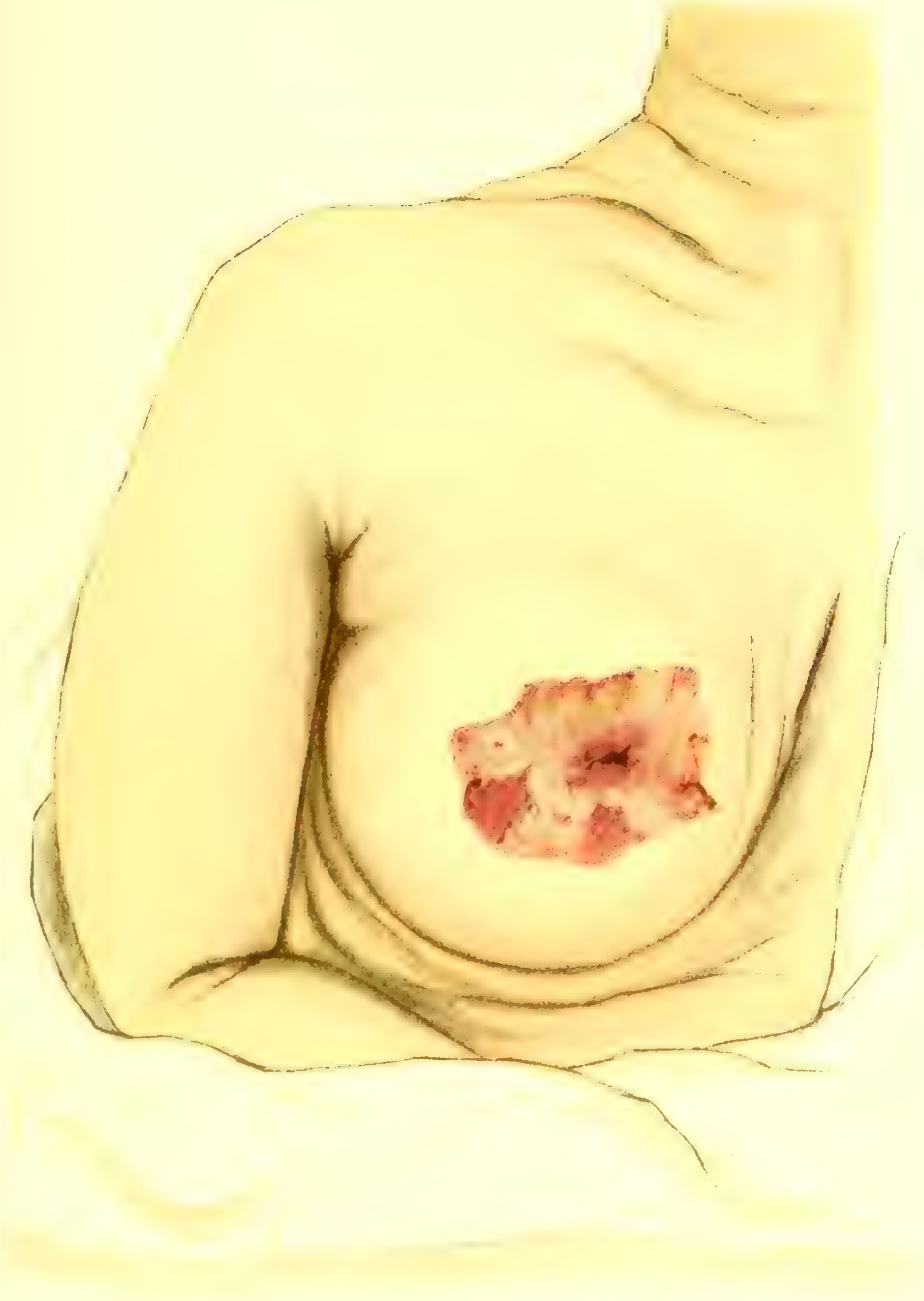
The organs and tissues primarily affected by carcinoma are not necessarily or most frequently those affected by secondary carcinoma. Thus, the glands, the skin, and the mucous membranes, are rarely the seat of secondary tumors, but the bones and the brain, parts never attacked by the primary disease, are among the most common, next to the lungs and the liver, of the parts in which secondary tumors grow.

Etiology of Carcinomata.—The age and sex of persons subject to carcinoma have been touched on in the preceding paragraphs. Here it may be added that although carcinoma attacks some parts of the body much earlier than others, it is rare in any part in persons under thirty years of age. It is sometimes seen in the testicle in men little over twenty years, on the labia in girls of scarcely twenty, in the breasts of women between twenty and thirty years. From thirty-five to fifty years it is met with frequently in the breast, the vulva, and the uterus, on the tongue and the penis, in the testis and the bladder. The carcinomas of the lip and the œsophagus are more frequently noticed at a later age—from forty-five to sixty-five. The sexes are very unequally exposed to the occurrence of carcinoma, on account of the great liability of the female organs of generation to the disease. The breast, for example, furnishes a large proportion of the sum total of all carcinomas, and the vulva and the uterus are more often affected than the penis, the scrotum, and the testicle. The large statistics published on these points in the death registers of various countries might be adduced to prove the truth of these statements, but they are not accurate enough in several points. The various kinds of malignant tumor are not sufficiently distinguished, and the certificates are often not based on examinations after death, in cases in which the precise seat and nature of the disease could only be discovered by an autopsy. In several parts which possess the same structure and function in males and females, carcinoma is much more prevalent in the former; this is the case in the tongue, the œsophagus, and, above all, in the lower lip.

The difference is attributed to habits and conditions which are much more common in the stronger sex; the habit of smoking undoubtedly predisposes to the formation of epithelioma of the lip, and it is a remarkable circumstance that more than one of the few women who have suffered from this disease have been habitual smokers; the same habit, and the results of past syphilis and intemperance, tend to carcinoma of the tongue; dram-drinking and coarse habits of eating and drinking are thought to be powerful agents in producing carcinoma of the œsophagus. Although I quite admit that these are all agents in the production of carcinoma, chiefly, perhaps, by causing irritation and chronic inflammation in structures which are prone to carcinoma, it is difficult to believe that the enormous disproportion in the two sexes can be due solely to these causes, and I am driven to suspect the existence of some other essential difference of which at present we are ignorant. Among the causes to which epithelioma of the tongue is probably in many cases rightly ascribed, is the rubbing or scratching of carious teeth. But carious teeth are as common in women as in men, and epithelioma from this cause ought certainly to be as frequently observed in one sex as in the other.

Development of Carcinomata.—The manner in which a carcinoma is developed from epithelium can be clearly discerned in the tumors of certain parts. Thus, squamous-celled carcinoma of the tongue is formed by proliferation of the cells of the deeper layers of the epidermis of the mucous membrane, and by the consequent ingrowth of the interpapillary processes into the subjacent tissues. In carcinoma of the antrum, the form of the mucous glands is often for a long time maintained, but their size is greatly increased, and the epithelium, in place of forming a thin lining for each tube or sac, is vastly thickened, and consists generally of several layers of cells, while the cells exhibit many signs of activity and proliferation. In carcinoma of the breast, a similar glandular arrangement can often be distinguished even when the disease is far advanced, if not in the central, yet plainly in the peripheral portions. But the tumors of the breast which offer the greatest facilities for these researches, are the carcinomas which have been preceded by eczematous conditions of the nipple and areola. (Plate XXIII.) The activity and proliferation of the epithelium of the nipple is continued into the mouths of the galactophorous ducts (Plate XXI., Fig. 27); the same activity and proliferation can be traced along the ducts, in which the form of the cell is usually changed, and a spheroidal cell is substituted for the columnar cell which naturally prevails there (Plate XXI., Fig. 28); these morbid conditions are continued deep down into the substance of the mammary gland, where the sacs become similarly affected. Coincident with the changes in the ducts and glandular epithelium, increased vascularity and the collection of cells resembling leucocytes are observed in the connective tissue immediately surrounding the glandular apparatus. But no direct connection can be traced between the changes within the ducts and sacs and those without them, and

PLATE XXIII.



Eczematous Nipple and Areola ("Paget's Disease"),
associated with carcinoma of breast and axillary glands.
(From a patient in the Hospital of the University of Pennsylvania.)

H. BENCKE, LITH. N.Y.

the latter are subordinate in character and degree to the former. Not until the disease is advanced, and a definite tumor has been formed, which can be recognized with the naked eye as carcinoma, are cells resembling those within the ducts and sacs found in the surrounding tissues. Birch-Hirschfeld[1] has shown that the changes in the testis, which lead to carcinoma, commence in a similar manner in the epithelium, and Carmalt[2] has performed a similar service in respect to epithelioma (squamous-celled carcinoma) of the œsophagus. The multiplication of the epithelial cells appears to be, in most instances, by endogenous growth, and the young cell or cells can often be discerned within the parent cell. But multiplication by division appears also to take place.

On the whole, it is more difficult to trace the extension of the processes which are observed within the glandular apparatus of an affected organ into the surrounding tissues. At one time, I was disposed to believe that when the ducts and sacs became filled and distended with cells, their walls gave way, and the epithelium escaped into the surrounding tissues; and I still think that this is one of the ways by which the epithelium, so to speak, escapes. But that there are other ways by which the connective tissues become infiltrated with epithelial cells, I cannot doubt. From specimens which Mr. Eve has shown me, it appears probable that instead of, as it were, dribbling out on all sides of the distended sacs, the epithelium may put forth buds or processes of cells at one or more points, and that these may grow till they become long bars or solid cylinders of cells in the interstices of the connective tissue. Again, Mr. Cripps[3] has shown that, in columnar-celled carcinoma of the rectum, the nuclei of the columnar cells which line the follicles pass out through the basement membrane and wall of the follicles into the surrounding tissues, and there, becoming surrounded by protoplasm, develop into new cells similar to those from which the nuclei escaped. The grouping of the nuclei, and consequently of the cells, resembles that of the cells in the follicles, and thus the follicular structure is maintained in all but the most rapidly growing rectal carcinomas. I have not yet been able to convince myself of the correctness of the infection-theory as applied to the growth of carcinoma; yet it is affirmed by many good observers that "indifferent" corpuscles, connective-tissue corpuscles, and endothelial cells, are all capable of being converted into epithelium in the immediate vicinity, and under the influence, of growing carcinoma. If there exist this capacity, I might almost say readiness, on the part of various cells to assume the form and properties of carcinomatous epithelium, it has always seemed to me a singular circumstance that the cells in a lymphatic gland are not infected almost *en masse*. But, in fact, in the carcinomatous invasion of lymphatic glands, the new cell-growth adopts a determinate course, passes between or around masses of lymph-corpuscles, but appears to produce no other effect upon them than that which may be ascribed to inanition.

Again, there is uncertainty respecting the source of the stroma of most forms of carcinoma, and the manner in which it is produced. It is, for the most part, fibrous tissue, and, in the hardest varieties of spheroidal-celled carcinoma, a coarse and tough fibrous tissue. It may contain no cellular elements of its own, and may inclose only the cells proper to the carcinoma, or it may be infiltrated with cells like leucocytes, respecting the origin and precise nature of which there exists a wide diversity of opinion. Some pathologists aver that they are wandered-out corpuscles of the blood; others, that they are derived by proliferation from the connective-tissue corpuscles, or

[1] Archiv der Heilkunde, Bd. ix. S. 538. 1868.

[2] Virchow's Archiv, Bd. lv. S. 481. 1872.

[3] Cancer of the Rectum, chapter iii. London, 1880.

the endothelial cells; others, that they are the escaped nuclei of the epithelial cells. I am disposed to regard them partly as wandered-out corpuscles of the blood, but chiefly as the offspring of connective-tissue corpuscles, in either case the result of the irritation caused by the near neighborhood of the excited and active epithelium. A large part, if not all, of the fibrous stroma of many carcinomas is certainly the fibrous tissue of the part in which they are developed. But where this is very scanty, it may be replaced or supplemented by a new formed stroma. In proof of this, I may mention that I once examined a recurrent carcinoma of the breast, a lump measuring an inch and a half by nearly an inch, and having the thickness of an inch. It grew close to the corner of a scar of the previous operation where there had been, before its growth, very little tissue of any kind over the muscle. This tumor presented an alveolar structure such as the original tumor had probably presented, but, in place of old and perfect fibrous tissue, the stroma was composed of fibre-cells which had not yet developed into fibrous tissue. To what extent the new formation of fibrous tissue takes place in most primary carcinomas, it is impossible to say; but that there is a new formation in most of them, is probable. The shrinking of a scirrhous carcinoma is probably in a measure due to a contraction of the newly-developed fibrous tissue, similar to that which occurs in scars.

APPEARANCES AFTER REMOVAL; METAMORPHOSES AND COMBINATIONS.—The *macroscopic characters* of carcinoma depend, to a certain extent, on the subclass to which the tumor belongs, but there is great variation in the appearance of different tumors of the same subclass. Some general characters are, however, common to most, if not to all, of them. The absence of capsule, for example, is almost universal. A carcinoma may be perfectly circumscribed, and its outline may be clearly drawn against the surrounding tissue, but a fibrous capsule inclosing it is a great rarity. There are two chief types of carcinoma, recognized generally as the *hard* and the *soft*. The former seldom forms a tumor of large size, and is often very small. It may have existed many years and yet be no larger than a walnut. This, of course, is rare; for, indeed, it is not usual to meet with a case of carcinoma of any form in which the disease has existed many years. It feels and cuts firm or hard, or even very hard like fibro-cartilage, and is heavy and inelastic. Its cut surface is usually concave. The aspect of the cut surface is homogeneous, or fibrous with glistening bands of fibres crossing it in various directions, but presenting no definite arrangement such as is seen in fibrous tumors. It is not often lobed. A thick creamy fluid may usually be scraped off the section. The general shape of the tumor may be that of a rounded and tuberous mass, clearly defined—a mass which may be dissected away from the adjacent parts; or it may roughly preserve the form of the gland or part in which it has been developed, and may be connected with the surrounding or more distant tissues by long straggling arms or processes which, with its queer-shaped body, lend to it some resemblance to a crab, whence the names cancer and carcinoma.

The *soft* carcinomas form, usually, much more bulky growths, and are much more vascular than the hard tumors, although the latter are usually well supplied with vessels. They may be very soft—so soft that they will not hold together—or as firm as firm fat or soft fibrous tissue. They often form large, rounded masses, and are not uncommonly lobed. On section they exhibit the opaque-white color and creamy appearance of brain-substance, blotched and dotted with red, or of a gray color and more translucent aspect. Although these are the two chief types of carcinoma, they comprise scarcely more than half of all carcinomas. They include, however, a considerable number of the spheroidal-celled tumors, and a few of the squamous-celled and columnar-celled growths. The majority of the squamous-celled tumors are formed of a dense, opaque, dull-white material, presenting no trace of fibrillation, but containing usually numerous plugs of yellow, cheesy matter. They are generally friable, but are sometimes very tough. They very rarely form large tumors; indeed, there is often nothing which deserves the name of tumor, for, beneath the ulcer, which almost invariably forms, there exists only a layer of carcinomatous material, from a line to half an inch in thickness, with a notched or fringed border abutting on the subjacent parts.

Whatever be the appearance of the disease, one character is almost always apparent in a carcinoma, that of infiltration. In the section on sarcoma it was pointed out that the tumor is often circumscribed and encapsuled, and that the infiltration of surrounding tissues, which almost invariably occurs, is veiled, and may not be suspected. In carcinoma the case is different; infiltration is not only present, but is usually plainly visible. The tumor is, in very many instances, not a separate mass, but an altered condition of the part in which it grows. Again, the carcinomas are very vascular, or, if the tumor itself be not very vascular (for example, an epithelioma), the vessels which supply the parts immediately around it are always large and full.

Other general characters of carcinoma depend upon the part attacked, and upon changes which the tumor undergoes. Thus, the hard and the soft varieties, and the typical epitheliomas, are all liable to *fatty* and *caseous degeneration*, and these changes, when they are extensive, naturally produce a striking effect on the appearance of portions of the tumor. The hard carcinomas, of the breast especially, are prone to shrink, and, by shrinking, become still harder, and draw in toward the tumor all the surrounding tissues, so that distortion, puckering, and an appearance of scarring, are produced. Organization, with the exception of *fibrification*, is very rare in carcinoma. *Bone* and *cartilage* are scarcely ever met with; nor is *calcification* more frequent. But there is one transformation of the tissues of carcinoma which is not by any means uncommon in the tumors of several parts, a transformation so striking in the effects which it produces that it has led to the belief that the tumors which were affected by it belonged to an entirely separate class of carcinomas; it is the *colloid* transformation. Colloid carcinomas are almost always easily recognized by their gelatinous appearance, and by their locular structure. The loculi or alveoli are, in some tumors, very large; in other tumors so small that they present the appearance of a fine network, with meshes filled with jelly, or viscid, transparent fluid, softer and more diffluent than jelly. Colloid carcinomas are met with in the abdomen, in connection with the omentum and mesentery, and in the stomach and intestines down to, and within, the rectum. They occur, too, occasionally in other parts, such as the breast. They often form large masses, and spread, along the intestine especially, over many inches or even feet. They grow, for the most part, slowly, and are less malignant than the carcinomas of the same parts which are not colloid, as if the colloid change of structure had involved some change of property or capacity in the tumor, fortunately in the direction of rendering it less capable of mischief; yet they run the same course as other carcinomas of the same part, but are slower in every stage of it. Thus, the colloid tumors of the breast are slow of growth, late in returning after they have been removed, late in affecting the lymphatic glands, and slow to affect other organs. But they may do all these things, provided that sufficient time is granted them. The reasons for believing colloid carcinoma to be only a modified form of one of the subclasses, are shortly these: it is sometimes found in combination with one of the other forms, the spheroidal-celled especially, and the gradual transition of the one into the other can be clearly traced; the cells which are seen in the colloid material resemble those found in other carcinomas; and the course of the disease is similar to that of other carcinomas of the same part, but somewhat more prolonged.

True *combinations* of carcinoma with other tumors are not common. Occasionally a combination with adenoma or fibro-adenoma is observed in the breast, and the supposition is that an adenoma or fibro-adenoma of the breast has been transformed into a carcinoma. Combinations with papilloma also are met with. An epithelioma may commence as a simple warty growth, and the warty condition may remain long after the epithelial transformation has occurred.

Again, it is probable that combinations of sarcoma and carcinoma do occur. I have once or twice seen tumors of which there was great difficulty in deciding whether the disease was sarcoma or carcinoma. The elements of both kinds of tumor appeared to be mingled in such a manner that a combination-tumor was suggested. It must be remembered, however, in relation to such tumors, that the connective tissue of a carcinoma may consist of spindle-cells or fibre-cells, as in the recurrent carcinoma of which mention has been made.

What has been already said of the *microscopic characters* of carcinoma need only be supplemented here by one or two remarks on its alveolar structure. This is not nearly so universal as might be supposed from the importance which has often been attached to it. It scarcely exists in squamous-celled carcinoma (epithelioma), and is almost always absent in columnar-celled carcinoma. In the young spheroidal-celled tumors, the alveoli are for the most part the full sacs or tubelets of the gland. In the older tumors, the connective tissue forms spaces or alveoli of various shapes, in which epithelial cells are closely packed. In the soft tumors the alveoli are large and numerous, and the stroma is scanty; in the hard tumors the stroma is abundant, and the alveoli are small; while in the withered, scirrhous tumors the stroma is very coarse and plentiful, the alveoli are reduced to mere fissures, and the cells are shrunken or degenerated to a mass of molecules.

Carcinoma, like sarcoma, is liable to inflame and even suppurate, but the liability is not great. Occasionally the formation of a carcinoma is preceded by the signs of inflammation, or is ushered in by an inflammation, a circumstance doubly interesting, since it complicates the early diagnosis and opens the important question of the relations of carcinoma to inflammation. The ulceration of carcinomas is much more frequently observed than the ulceration of sarcomas. The tumors of the skin and mucous membrane almost invariably ulcerate, and the tumors of the breast, if they be left long enough without operation, very frequently ulcerate. Not so the carcinomas of the testis, where the tumor may attain a large size and produce numerous secondary tumors without breaking. The character of the ulcer is usually significant of the disease. The edges are often raised and nodular, and the surface sometimes glazed and tuberous, sometimes ragged and sloughing, sometimes deeply excavated and irregular, generally foul, and scarcely ever healing, while in every case the ulcer is a loss of substance of the tumor which forms its immediate base and edges. Thus, in the breast, the tumor becomes adherent to the skin, which is red or livid when the adherence is complete, and becomes actually a part of the tumor. When the ulcer forms, it is as if a hollow were scooped out of the substance of the mass.

Symptoms and Course of Carcinomata.—The clinical characters of carcinoma naturally vary with the form of the disease and with the part attacked, and there are very few characters which are common to the carcinomas of all parts. Among these, the character of infiltration is one of the most prominent. In the skin, the tongue, the œsophagus, the breast, the testis—in truth wherever carcinoma grows—it infiltrates the affected part. The outward signs of infiltration are induration and immobility. The degree of immobility depends on the nature of the part affected and the stage of the disease. An epithelioma is, at its commencement, fixed to the skin, or mucous membrane, and moves only with these structures, but in a later stage it may connect them with deeper and less movable parts, and the fixation may become complete. A carcinoma of the mamma is, in its earliest condition, an indurated portion of the gland, but is as freely movable as the gland itself. As the disease advances, it may attach the affected portion of the gland to the skin, or, worse still, to the pectoral muscle, or even to the ribs, when the immobility becomes complete. A carcinoma of the testis affects, as far as its clinical characters are concerned, the entire organ; the scrotum may never become adherent, and the impaired mobility which is noticed in the later stages is generally due to the size and weight of the tumor, and to the thickening and stiffening of the cord. Continued growth, and, where the disease is superficial, continual advance of ulceration, are also characters significant of carcinoma. The exception which occurs in the shrinking of some hard carcinomas of the breast, must of course be borne in mind. In most instances, the growth is not only continuous, but rapid in comparison with the growth of all other tumors of the same part except sarcoma. Few carcinomas attain a large size; indeed, their largest bulk is insignificant in comparison with that of some of the sarcomas, and of many of the innocent tumors. A primary carcinoma may be of quite small size, even when it is the parent of numerous secondary tumors, and, when general carcinosis is far advanced. Multiple, primary carcinomas are very unusual, much more so than multiple, primary sarcomas.

The progress of a carcinoma is almost invariably from bad to worse. Spontaneous cure, even by sloughing of the tumor, is almost unknown. But the natural duration of the disease, and the manner in which it terminates, are variable, and influenced by many circumstances. Even tumors of the same organ are subject to marvellous variation in the length of life vouchsafed to the patient. A carcinoma of the breast may run its course with every detail of malignancy in three or four months; and, on the other hand, well authenticated cases are on record, in which carcinomas of the breast have existed from twelve to twenty years, and have not then produced such extensive morbid changes as the more rapid tumors have effected in a quarter of a year. But the general tendency of the disease is to infiltrate and fasten together adjacent structures, to affect, in many instances, the neighboring lymphatic glands, and to produce secondary tumors in other tissues and organs.

The *affection of lymphatic glands* is of such frequent occurrence that it has been regarded as essentially a character of carcinoma, almost alone sufficient to distinguish it from other malignant tumors. This is a false impression, which is corrected in this, and in the section on sarcoma. All carcinomas do not affect the lymphatic glands, but all carcinomas of certain organs and tissues affect them. The glands first affected are those which stand in a direct anatomical relation to the part in which the primary disease is situated; but the period at which the lymphatic glands become affected is subject to the widest variation. Thus, a carcinoma of the breast may be first noticed simultaneously with affection of the axillary glands, and, although there is no doubt that the latter is secondary to the former, there is very little doubt that the interval between the two diseases has not been very long, perhaps only a few weeks. In contrast to this rapidity of extension, there are cases of carcinoma of the breast in which affection of the glands has been deferred five, seven, or eight years. When a gland is once involved, although the affection may have been long delayed, the disease often spreads quickly from gland to gland, and this before any individual one of a group of glands has acquired a notable size. Nothing is more deceptive than the impression gained by feeling a full axilla. What has appeared to be a single, slightly enlarged gland, proves, in many instances, on opening the axilla, to be only one of a large group of diseased glands, each of which is of considerable size.

Two very interesting questions in connection with this subject deserve attention: first, whether glands which are enlarged in the immediate neighborhood of a carcinoma, and in the lymphatic course, are necessarily carcinomatous; second, whether glands which are not obviously enlarged may nevertheless be carcinomatous. The answer to the first question is manifestly negative. A gland beneath the jaw, in a case of epithelioma of the tongue, may be enlarged, and the enlargement may be due to the presence of the epithelioma, yet there may be no carcinoma in the lymphatic gland. In proof of which, in more than one instance, such a gland has been allowed to remain when the primary disease has been removed; the swelling of the gland has entirely subsided after removal of the ulcer, and the patient has been free from all signs of carcinoma after the lapse of several years. It is, however, quite clear that, unless there be some well marked contraindication to the removal of such glands, no reliance should be placed in practice on this exceptional condition. The second question may be answered in the affirmative. For it is by no means an unusual circumstance, after an operation for carcinoma, to see the glands slowly enlarge, although at the time of the operation they appeared to be quite healthy, or, at least, no enlargement of them could be discovered. Of such cases it must be surmised, either that a separate outbreak of carcinoma has occurred in the lymphatic glands, or that they were already affected when the primary tumor was removed. It need scarcely be stated that the latter is the correct view: if there were no other proof, the histological resemblance of the disease of the glands to the primary disease would suffice to decide the question.

In some cases, cords formed by thickened or swollen lymphatics can be felt between the enlarged glands and the primary disease. But this is not invariably the case: indeed, the anatomical relations of the parts affected may render it impossible to distinguish these lymphatic cords even if they exist. Where they can be distinguished, they should be regarded as undoubtedly carcinomatous in all questions relative to treatment. Their structure, and the manner in which the glands become affected without disease of the intervening lymphatics, were discussed in the introductory portion of this article.

The production of *secondary tumors* in structures other than the glands, depends partly on the seat of the primary affection, and perhaps partly on the variety of the carcinoma. The secondary tumors usually bear a strong resemblance to the primary disease, so much so that the characters of a secondary tumor of the liver may indicate the nature and even the probable seat of the primary growth. The liver and the lungs are the parts most frequently attacked by secondary tumors; but the skin, bones, brain, heart, kidneys, and other tissues and organs, are also liable. The soft, spheroidal-celled carcinomas of such parts as the breast and testis are the tumors from which the widest dissemination may be expected. Slowly growing and hard squamous-celled carcinomas (epitheliomas) of the lip and scrotum exhibit very little tendency to dissemination. As in the affection of lymphatic glands, so in the formation of other secondary tumors, there exists the widest difference in respect to the period at which the dissemination is effected. The same kind of tumor, in the same parts, may produce numerous secondary growths within a few weeks or months of its first appearance, or not till after many years.

The germs of the secondary tumors are carried in most instances by the blood, and thus the lungs, whose capillaries are the first to receive the returning blood, are exposed above all organs to contagion. The blood from tumors of the alimentary canal, the spleen, and the pancreas, first passes through the capillaries of the liver, and to this cause the frequency with which secondary tumors of the liver occur is partly to be attributed. In connection with this point some singular facts deserve to be recorded. The blood from a part in which a carcinoma is situated may be returned partly through the portal, partly through the general circulation. Facilities are thus afforded for the introduction of tumor-germs into both liver and lungs. But, while the former is abundantly inoculated, and becomes the seat of numerous growths, the latter are quite free from secondary tumors. An illustration of these conditions may be observed in squamous-celled carcinomas of the cardiac orifice of the stomach; or, rather, of the termination of the œsophagus. It might be imagined that the liver was preferred in these cases on account of its proximity to the cardia; but that it is not merely a question of proximity, may be assumed when it is found that squamous-celled carcinomas of the higher portions of the œsophagus scarcely ever produce secondary tumors in the lungs, and, in the few instances in which they do so, probably inoculate the lungs through the air-passages rather than through the bloodvessels. From a knowledge of this fact, it may be argued that the tissue of the lungs does not afford a suitable nidus for the reception and growth of squamous-celled carcinoma originating in the œsophagus, unless, perhaps, under peculiar conditions—such, for example, as the introduction into them of an actual mass or lump, such as may be conveyed by the inspired air. It may, on the other hand, be argued that the tissue of the liver affords a favorable nidus, and that the disease seizes greedily on it through the opening which is offered by the portal circulation. If this be admitted, the further question may be asked, why germs which have passed through the capillaries of the lungs are not conveyed to the liver and other organs, whose tissues are better fitted to receive and mature them? Possibly they do pass through the pulmonary circulation; if so, it must be assumed that their vitality is destroyed, and that they are rendered incapable of development by changes effected in them on their passage. If they are arrested in the lungs, it must be assumed that they remain immature, or perish in consequence of the unsuitability of the nidus.

From the foregoing considerations arise others equally interesting and important. Supposing, as appears probable, that secondary tumors are due to the conveyance by the blood of germs derived from the primary disease, why is the entrance of the germs into the blood deferred for months or even years, when, as we know full well, the vessels in the interior of a malignant tumor are, in most instances, very weak-walled and easily penetrated? Again, when the germs have certainly made their way into the blood, and fresh germs may be assumed to be continually entering the blood and circulating through the body, why is the dissemination in most cases so limited? Clauzel[1] has shown that, in certain cases of melanosis, colored granules or molecules are easily detected in the blood, the urine, and the vomit, and that the presence of these bodies indicates the occurrence of dissemination. If we regard these bodies as the germs of the disease, we must acknowledge that they exist in large quantity throughout the body, while the dissemination may be limited to a single tissue or organ. In part answer to these inquiries, I think the following propositions may be assumed: That germs of tumors are often present in the blood long before dissemination takes place, but, either from defective vitality in themselves, or from too great vitality and consequent power of resistance in the tissues, do not obtain a hold even in suitable soils; for it must be admitted that all soils are not equally suitable for the reception and development of the germs of tumors. Second, that the dissemination is not necessarily associated with great activity of the primary tumor, although the most active primary tumors are those which generally are earliest and most widely disseminated. For we occasionally meet with cases in which dissemination has occurred in connection with old and withered scirrhous carcinomas, whose very existence has almost been forgotten, and which have exhibited no signs of renewed activity. There may, of course, be a revival of activity in the outlying parts of such a tumor, of small extent, and concealed in the depth of the tissues in which the tumor lies; but, if the case be judged on its apparent merits, the original tumor is perfectly quiescent. In all considerations relating to the occurrence of secondary tumors, the possibility, nay, probability, must be borne in mind, that each secondary growth may be the parent of later secondary growths, and that therefore it is not necessary to trace back to the primary growth the origin of every secondary tumor. Thus, a primary tumor of the breast may be the source of secondary tumors in the lungs, and these in turn of secondary—or tertiary, in point of origin—tumors in the liver and the kidneys.

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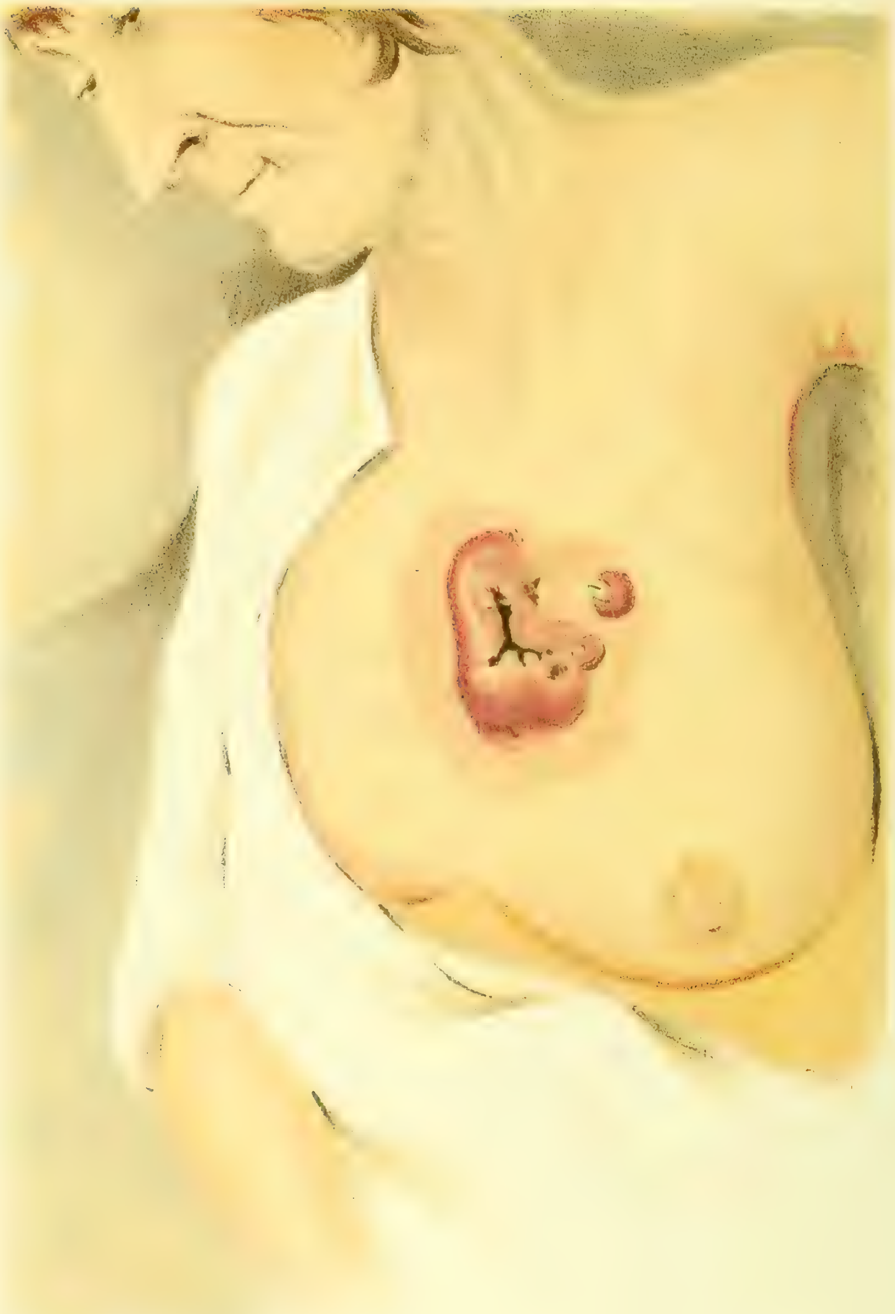
[1] Thèse de Paris, 1874.

Diagnosis.—The diagnosis of carcinoma, that is of carcinoma of external or easily accessible parts, is in most instances easy. The comparatively rapid growth of the tumor, the manner and rapidity of its progress, the implication of surrounding structures, the affection in many cases of the neighboring glands, and in a few cases the dissemination of tumors, are signs sufficient to enable a surgeon to distinguish carcinoma from any of the innocent growths. The diagnosis between carcinoma and sarcoma is, of course, not so easy; in some instances, and more particularly in the tumors of certain parts, it may be impossible. Thus, between sarcoma and carcinoma of the testicle it may be quite impossible to distinguish, even after removal, unless the presence of cartilage proves the disease to be sarcoma. But in some parts which are liable to both diseases, the diagnosis is rendered much less difficult by certain peculiarities in the one tumor which are rarely exhibited by the other. In the breast, sarcoma is in the first instance, and sometimes till late in the disease, usually much more movable than carcinoma; it frequently contains cysts; it forms a much more bulky tumor; it does not affect the axillary glands; and the ulceration from which it sometimes suffers differs widely from the ulceration of carcinoma. The characters of the ulcer in both diseases have been described and need not be repeated. Again, extreme difficulty is sometimes experienced in distinguishing between carcinoma and inflammatory swelling. Generally, the symptoms of inflammation are absent in cases of carcinoma. But they may be present certainly in as great measure as in some chronic inflammations, and the ill-defined tumor with the slight signs of inflammation renders the diagnosis very uncertain. The difficulty is made greater by two circumstances: first, a carcinoma may become actually inflamed, and suppurate; second, an inflammation with or without suppuration may immediately precede the formation of a carcinoma. In the presence of these complications the diagnosis may be at first impossible, and in many cases can only be arrived at by careful watching of the case. It should be borne in mind that even the presence of enlarged glands is by no means incompatible with inflammation. The enlarged glands of inflammation are, however, generally less hard and more tender than those of carcinoma. The diagnosis of carcinoma depends, in the large majority of cases, on several or many associated conditions. Thus, the age of the patient is always a matter of importance; for, however closely a tumor in a child may resemble carcinoma,

PLATE XXIV.



Atrophic or Withering Carcinoma of the Breast in an old Woman.

(From a Patient in the Hospital of the University of Pennsylvania.)

H. BENCKE, LITH. N.Y.

the tender age of the patient entirely shuts out the probability of carcinoma. The situation of the tumor is not less important. Not only are certain situations much more liable than others, but some situations, as the bones and muscles, are impossible to primary carcinoma. The sex of the patient often affects the diagnosis, in the case of squamous-celled carcinoma of the lip or tongue for instance. These and other similar points will therefore always be taken into the account, in addition to the local characters of the disease.

PROGNOSIS.—The prognosis of carcinoma is invariably bad, for the natural progress is in every case toward death. But there is the widest diversity, both in the duration and in the course of the disease. There is great diversity not only between the carcinomas of different parts of the body and between different forms of carcinoma, but even in a number of cases of carcinoma of similar structure of the same part. Thus, although spheroidal-celled carcinoma of the breast is in the majority of cases fatal in from two to three or four years, patients have been known to live for more than twenty years with this disease. The great differences which exist in the tendency to dissemination, and in the extent to which dissemination takes place, have been spoken of in previous pages. It may generally be foretold with certainty that a patient with carcinoma of the tongue or the œsophagus will not live a year and a half, and that a patient with carcinoma of the upper portion of the face, especially in the neighborhood of the orbit (rodent ulcer), will in all probability live for many years. It may with equal certainty be foretold that the disease in the last case will, if unchecked, produce extensive and hideous ravages; and it may be said of the first two cases that the patients are killed thus early owing to the advantageous position which the carcinoma unfortunately commands. Operation, if very free and early, may produce a most beneficial effect on the prognosis, but the effect is largely influenced by the situation of the growth. The best results of free removal are observed in the case of squamous-celled carcinoma of the lip and scrotum, where the operation not infrequently is effectual in completely curing the disease. A good result may also be expected from the removal of squamous-celled carcinomas of the skin of various parts, if the disease be not advanced. The more slowly growing carcinomas of the rectum may be removed with a fair prospect of success. But the prospect becomes more gloomy in the case of carcinomas of the testis and the breast. And in those of the tongue and upper jaw, only a faint hope can be entertained that the disease will be completely arrested, or even long retarded.

TREATMENT.—In spite of the effect which the removal of a carcinoma may produce on the prognosis, it does not follow that an operation should be practised on every tumor which is removable. It may be laid down as a general rule, that all cases of carcinoma which are uncomplicated, and in which the tumor is accessible, should be treated by free operation. But each individual case must be judged on its merits, and the considerations which guide our conduct in deciding on operations for other causes, must not be lost sight of in the treatment of carcinoma. It is often prudent, and in the best interests of the patient, not to remove a shrivelled carcinoma of the breast (Plate XXIV.), even when the tumor is easily removable and there is no glandular enlargement. For it sometimes appears as if a disease which was previously quiescent, and likely to remain almost unchanged during years, is started into fresh activity by an operation. It recurs, and the recurrent growth exhibits an activity and power which would never have been looked for in the primary disease. Ulcerated carcinomas of the breast, with wide affection of the integument, especially when there are many separate nodules in the surrounding skin and subcutaneous tissue, are very unsuitable for operation. It need scarcely be said that affection of the neighboring lymphatic glands seriously complicates the question of removal of a carcinoma, and may render inadvisable an operation which might otherwise be undertaken. But glandular affection must not be allowed to exercise too powerful an influence in deciding against an operation, provided that the glands, the primary disease, and the intervening tissues, in which the lymphatics lie, can be freely removed. That the prognosis is less good in such a case, admits of no question; for, in addition to the increased difficulty in completely removing the disease, affection of the glands indicates a more advanced stage of malignancy of the carcinoma. But the success which, of late years, has attended operations conducted on a larger scale than heretofore, justifies the operative treatment of such cases. Recurrence of a carcinoma, either in the site of the original tumor, or of the glands which have been removed, may be met by repeated operations, provided that the recurrent disease be easily accessible; and at each operation every care should be taken to cut wide of the disease. The dissemination of carcinoma generally places it beyond the reach of surgery; even if the disseminated tumors be removable, their presence indicates a malignancy so advanced that operation would but add one more distress to those which already afflict the patient. Where a carcinoma is so situated that it can be very completely removed by amputation of a limb, that method should always be preferred, unless the disease be a small skin tumor of recent origin, and still limited to the superficial tissues.

The *spheroidal-celled* or *glandular-celled* carcinomas form perhaps the most common of the three subclasses. Their chief seat is the female breast, but they occur also in the male breast, in the parotid and other salivary glands, in the testicle, the antrum, the liver, and other organs. Secondarily, they affect the lymphatic glands and the bones, the lungs, and other of the viscera. They form in most instances definite tumors, and comprise most of the typical hard and soft carcinomas. Their origin and minute structure have been sufficiently described, and it is only necessary to repeat here that the typical alveolar structure of carcinoma is chiefly to be found in the tumors of this subclass. They are very liable to fatty and caseous degeneration; and most, if not all, of the true colloid carcinomas are glandular-celled tumors. Wasting or withering belongs also almost exclusively to these tumors. Combinations with adenoma or fibro-adenoma are occasionally met with. Cysts are formed in some of the glandular-celled carcinomas, but are not of frequent occurrence; cystoid cavities, due to degeneration and softening of the substance of the tumor, are much more common. In their gradual growth, these tumors implicate the skin and produce typical cancerous ulcers, but ulceration is usually late, and may never take place. As the disease advances, small secondary nodules may form in the integuments beyond the limits of the tumor, the glands may become enlarged, and the disease may be disseminated in the lungs, the liver, the bones, and other parts.

The *squamous-celled* carcinomas (epitheliomas) differ in several important respects from those which have just been described. They are for the most part superficial, affecting the skin and mucous membranes, but are occasionally found primarily in more deeply seated structures. They may grow from the skin of any region of the body, but they especially affect the face, the lower lip, the scrotum, and the anus. Of the mucous membranes, they attack those of the floor of the mouth and tongue, of the larynx and œsophagus, of the penis and vulva. Of the deeper structures, the upper jaw may be adduced as an example, almost indeed the sole example. Yet even here the disease almost unquestionably extends up into the antrum through the alveolar process of the jaw, from the mucous membrane of which it originates. Although a few of the epitheliomas produce soft tumors resembling the typical medullary cancer, the tendency of epithelioma may be said to be, not to produce a tumor. Scarcely has a lump formed, when its superficial portions, always closely connected with the skin or mucous membrane, ulcerate, and the appearance of the disease thenceforth is that of a foul and often ragged ulcer, with an indurated base and edges. The induration is in many cases so narrow that the tumor is lost sight of in the ulcer. In the microscopic structure, it must be pointed out that the alveolar structure is more often absent than present. The surface-epithelium can be seen dipping down in columns or masses into the subjacent tissues, and, as the deeper structures are reached, the epithelium advances into them in cords or cylinders of cells, always continuous, but pursuing an irregular course, now narrower, now wider, now putting forth knobs or buds, and always anastomosing at short intervals. The intervening space is occupied by the natural tissues, infiltrated with cells resembling leucocytes. The impression produced by the appearance of these cylinders of epithelial cells, is that they are formed and contained within some definite channels—an impression very likely to be true. The epitheliomas are liable to fatty and caseous degeneration, but rarely to the same extent as the spheroidal-celled carcinomas. The central cells of the characteristic cell-nests or epithelial globes are prone to colloid transformation. Wasting, such as happens to the spheroidal-celled tumors, is very rare.

The surface of an epithelioma is, not infrequently, papillary, for, with the tendency to grow downwards into the subjacent tissues, which is the essential feature of the disease, there is a simultaneous tendency to the putting forth of papillary outgrowths from the surface. These usually perish with the progress of the ulceration. Cysts are scarcely ever formed, and even cystoid cavities are rare. Multiple, primary epitheliomas, like multiple, primary carcinomas of every variety, are very rare. But after the primary disease has existed for a certain period, it is not unusual in some situations, as in the œsophagus, to observe a few, or even many nodules in the neighborhood of the primary epithelioma, or even extending a considerable distance beyond it. The lymphatic glands are liable to be affected by epithelioma, but the liability depends on the situation of the primary disease. Epithelioma may become generalized, but wide-spread dissemination is of rare occurrence, and it is not unusual for this disease to terminate without the formation of any secondary tumors. The liver and lungs are, perhaps, more frequently affected than other organs, but the kidneys and the heart may be the seat of secondary epithelioma, and growths may form in the bones and other tissues. The diagnosis of epithelioma, in all parts in which it can be reached, deserves especial notice. It is, for the most part, easy: the foul ulcer with its irregular surface and absence of granulations; the induration of the base and edges, often extending far beyond the ulcer; the spreading of the disease; its situation—these and other features in individual cases are quite sufficient to decide the nature of the malady. But it sometimes happens that great difficulty is experienced in making a diagnosis between epithelioma and syphilitic or tubercular ulcers. In such cases, the doubt may be dispelled by examining with the microscope a scraping of the surface of the ulcer, as recommended on a preceding page. The number and diversity of the epithelial cells, the mother-cells, and the occasional presence of epithelial globes or cell-nests, serve to establish the identity of epithelioma.

The general pathology of the *cylindrical-celled* or *columnar-celled carcinomas* is less intimately known than that of either of the preceding forms, partly because less attention has been paid to them, and partly because they have been regarded merely as a variety of the squamous-celled carcinomas, and have been included under the common term epithelioma. They are found in the rectum, which is indeed their chief seat, the intestines, the uterus, the antrum, and the sinuses of the nose, and in the ducts of some of the secreting glands, the pancreatic duct for example. They present the same characters of infiltration and absence of capsule as do the other carcinomas, and tend to early ulceration, like the epitheliomas. The surface of the tumor, too, is often papillary, or, as the processes are soft and long, it may more fitly be described as villous. The growth of the disease in connection with the surface-epithelium or superficial glands of mucous membranes, and its early ulceration, account for the association of this disease with squamous epithelioma. It produces, usually, a soft growth, which, however, feels indurated in comparison with the very soft surrounding structures. As in epithelioma, so in this disease, the tumor is often thrown in the shade by the size and importance of the ulcer. Allusion must be made to one important feature in the microscopic characters of this form of carcinoma, to the regularity, namely, of the epithelium, and to its arrangement as in the normal glands, in some of the more slowly growing specimens. The glandular arrangement is so perfect, or at least so little different from that observed in adenomatous polypi of the same part (as in the rectum), that, judging from the microscopic characters alone, it is sometimes impossible to distinguish between the columnar-celled adenomas and carcinomas. The general characters of infiltration and ulceration are, however, distinctive of the carcinomas. The columnar-celled carcinomas are not particularly liable to fatty or caseous degeneration; but they appear to be subject to colloid transformation. Cysts and cystoid cavities are rarely observed, yet cysts occasionally form by changes in the gland-like structures of which the tumor is composed. These tumors may affect the lymphatic glands, but do not necessarily do so. And they, more often perhaps than the squamous-celled carcinomas, are disseminated, attacking the liver with especial frequency.

Carcinoma of the Breast.—In illustrating the foregoing general account of carcinoma by short sketches of the carcinomas of special parts of the body the *breast* is naturally chosen to illustrate the spheroidal-celled carcinomas. But it must be borne in mind that the descriptions which have been given of hard and soft carcinoma apply nowhere so well as to the breast; that the remarks on the general and microscopic characters of the disease are in great measure dictated by our experience of carcinoma of the breast; that the statements respecting the limits of duration of cases of carcinoma are furnished in great measure by cases of carcinoma of the breast. I may now add that the breast is subject to spheroidal-celled and squamous-celled carcinoma, but to the former at least a hundred times as frequently as to the latter. The squamous-celled tumors are almost limited to the region of the nipple. The spheroidal-celled tumors attack every region of either breast almost without preference, but are, perhaps, a little more inclined to the upper and outer segment than to any other. The disease may occur in women after the twenty-fifth year has been attained, but is rare before the age of thirty. It commences in the majority of instances during the period between forty and fifty-five years. The mode of onset is usually by an ill-defined swelling in the substance of the mammary gland, or rather by an ill-defined induration of a portion of the gland, which at first slowly, then more quickly, grows. But the tumor may, when first noticed, be as large as a hen's egg, or may attain that size in the course of a month or six weeks.

In some instances, soon after the first appearance of the tumor, small nodules of carcinoma form in the skin and subcutaneous tissue of the mammary region. They are not necessarily limited to the mammary region, but may be spread widely over the back and front of the chest. In a few rare cases, the skin of the breast is extensively involved by carcinomatous nodules, while yet the mammary gland seems almost free from tumor. The nodules coalesce and transform the skin into a hard, stiff, red, or reddish-brown covering, through which the breast can be no longer felt, and to which the term "*squirrhe en cuirasse*" has been applied. It is very unusual for both breasts to be attacked simultaneously by carcinoma, or even for both breasts to be attacked at different periods in the same patient; but it is still more unusual for cancer to occur simultaneously in two or more parts of the same breast. The affection of the lymphatic glands, which is a part of the life history of carcinoma of the breast, may occur early or late in the disease—within two or three months of its first appearance, or not till after many (seven or eight) years. The average duration of the disease, if untreated by operation, is about two and a quarter years; but this period gives no idea of the shortness of the course in some instances, or of its extreme length in others. In the worst case which I have ever seen, death occurred within four months of the time when attention was first directed to the breast. Both breasts were affected, and completely transformed into masses of extreme hardness, but in neither case larger than the size of the breast before becoming diseased, and in neither case ulcerated, although adherent to the skin. The glands in both axillæ were enlarged and hard. The lungs and liver were occupied by cancerous masses, and other of the viscera were affected. This patient had early presented all the signs of cancerous cachexia; she had become sallow, had lost flesh and strength and spirits, and for days before she died was dusky and unconscious. On the other hand, I have seen an aged woman with a large ulcerated carcinoma of the breast of many years' duration. It was adherent to the pectoral muscle, and probably to the ribs, and extended round almost into the axilla. It discharged offensively and bled at frequent intervals, for the patient, who was insane, would tear her dressings off and even tear the wound, so that, on more than one occasion, it was thought that the hemorrhage would kill her. Yet she lived in this condition many years, and it was only towards the end that cachexia became established. A very large proportion of cases of mammary carcinoma are submitted to operation in spite of the admitted fact that the very large majority of those operated on die within a short period of the disease. Indeed, only a very small percentage can be claimed to be rescued from death by treatment.

The majority of patients treated by operation die with return of the disease *in situ*, or with enlargement of the axillary glands without local recurrence, or with recurrence in the axilla after removal of the lymphatic glands. In spite of these discouraging results the operation continues to be practised; nay, probably grows in favor. By many surgeons it is regarded as palliative, not curative: it is thought to diminish the liability to ulceration, inasmuch as the disease does not necessarily recur *in situ;* to remove a source of grave anxiety, be it only for a short period; to remove a cause of acute pain in certain instances; and to prolong life in a few cases, perhaps for a few months, or even more. By some surgeons it is looked on as offering a very slender chance of cure, yet still the only chance. And by a few surgeons it is regarded in a more hopeful light, not merely as a possible means of cure, but as a means which, used earlier and with greater freedom, would insure a good percentage of complete recoveries. Most surgeons remove the entire breast even when the tumor is comparatively small; but those who expect most from the operation, sweep the tumor and the breast completely off, together with a very wide area of integument, and, not content with removing axillary glands which are decidedly enlarged, search the axilla when no enlargement can be felt, and remove all the glands which can be found. That these large operations are fraught with grave danger to life is unquestioned; the ordinary operation of removal of the breast is a comparatively safe procedure, but these extensive removals result in a comparatively large percentage of fatalities. In spite of this, I am of those who advocate extensive operation where operation is deemed advisable, on the ground that the lesser measure often fails to afford even temporary relief, and that the larger measure has thus far proved much more successful in affording relief and effecting permanent cures. The experiment is still untried, how far success would be increased by much earlier operations than are customary at the present time, but the opportunities of carrying out the experiment seem yet to be far distant. Partly owing to the unfortunate tendency of women to conceal the existence of a tumor of the breast, partly owing to the ill-advice of many family doctors, carcinoma of the breast in a large number of cases does not come under the notice of the operating surgeon till three, four, six, or more months have elapsed since the first appearance of the tumor. By this time the skin is perhaps adherent; the tumor is no longer freely movable; the axillary glands are a little increased in size; and by thus much are the probabilities of complete removal diminished.

This sketch of carcinoma of the breast is of course very short, but a much more complete account of the disease will be found in the article on Diseases of the Breast.

Carcinoma of the Testicle.—The *testis* is subject to spheroidal-celled carcinoma. The disease may attack adults of almost every age, but is much more frequently met with after 35 years than earlier, and is most common between the ages of 35 and 45. It never affects both testes. It follows sometimes on a blow or squeeze, and is occasionally attributed to friction of the testis against the clothes. The tumor grows steadily and often quickly, at first maintaining the normal or nearly normal shape of the body of the testis, but after a time becoming more spheroidal or oval, and bulging here and there. The bulging parts are usually softer than the rest of the tumor, and sometimes fluctuate with the fluctuation of a soft solid. The epididymis soon ceases to be distinguishable as a separate body; the cord becomes a little thicker than its healthy fellow. If now the tumor be cut open, it usually presents the appearance of a typical soft cancer. The whole of the normal structure of the testis and epididymis is swallowed up in the disease, or a thin layer of testis structure may be spread out over a part, or all, of the surface of the tumor. Small areas of fatty or caseous degeneration may be present, but there is no mucous tissue, nor cartilage, nor bone. The mass is inclosed within the tunica albuginea, or a fibrous covering which has taken the place of the albuginea, and thus is separated from the scrotum, which is rarely adherent, even when the tumor is of large size. Ulceration is, therefore, a rare event. The layers of the tunica vaginalis are often adherent to each other, but the sac may contain fluid, even in considerable quantity. Cysts are less common than in sarcoma.

The *diagnosis* of the disease depends chiefly upon the continuous growth of the tumor, its shape, its general elasticity but unequal consistence, the character of the fluid drawn off by a puncture, the absence of the signs of inflammation and of adherence to the scrotum, unless the disease be far advanced. It must be borne in mind that sarcoma cannot, in most instances, be distinguished from carcinoma, and that the diagnosis is, in truth, between malignant disease, on the one hand, and innocent tumors, hæmatoceles, or inflammatory affections of various kinds, on the other hand.

Of the propriety of *castration*, in the absence of any contra-indication, at the earliest possible date, there can be no question; for, although the number of cases in which a patient has been authoritatively stated to be alive and free from all signs of carcinoma, a year or more after castration, are very few, still the percentage of such cases among those which I have collected, is sufficient to warrant the performance of the operation. Of 13 patients whose subsequent history was obtained, 2 were quite well 14 months afterwards, and 1 at the end of 3½ years. Were there no other ground for operation than the removal of a large, heavy, and sometimes painful tumor, that alone would justify castration, for local recurrence need only be apprehended when the cord is very large and obviously diseased.

The natural course of carcinoma of the testis is to produce affection of the iliac and lumbar lymphatic glands, very rarely of the glands in the groin, never, indeed, unless the scrotum is involved in the primary disease. The glandular enlargement probably takes place within a year or eighteen months from the first enlargement of the testis; but, on the other hand, it may certainly be deferred for eighteen months or two years, a circumstance which deserves every consideration, as it bears upon the usefulness of operation. Secondary tumors have been observed in the lung, the liver, the breast, the supra-renal capsule, and the omentum.

LINGUAL CARCINOMA.—The *tongue* appears to be subject only to one form of carcinoma, the squamous-celled (or epithelioma). The disease may attack any portion of the tongue, but generally affects its sides or borders. It is much more common, nearly six times, in males than in females; it is very rare before 30 years of age, and occurs in the large majority of cases in persons between 40 and 60 years. It may sometimes be traced to the long-continued irritation of a carious tooth, and may be engrafted on a tongue which has been, during many years, the seat of chronic superficial inflammation (ichthyosis, psoriasis, etc.). In no structure can the transition from chronic inflammation to epithelioma be more readily observed than in the tongue. The disease occasionally forms a definite tumor which presents the appearance of a soft cancer, but more often forms an irregular ulcer with indurated base and edges. Ulceration is almost inevitable, and usually occurs at a very early period. As the disease advances hemorrhage may take place, and the tongue may be bound down by extension of the growth to the floor of the mouth and gums; or the extension may be towards the tonsils and arches of the palate, or may involve the epiglottis and larynx.

The *diagnosis* of carcinoma must be made from tertiary syphilis (gumma and gummatous ulcer) and from tubercular ulcer. In most cases the age and sex of the patient, the situation of the disease, the surrounding induration, and the absence of other signs or history of syphilis and tubercle, serve to distinguish carcinoma. In cases of difficulty the surface of the ulcer should be scraped, and the product examined microscopically in the way already described. The lymphatic glands are involved in all cases which are not treated, or not cut short by accident. A very few months, three or four, will suffice in some cases for the disease to affect the glands, and the glandular affection is very seldom deferred longer than six months, probably never longer than nine or ten months. The glands in the immediate neighborhood of the primary disease are generally the first to become enlarged, but this rule is not without exception, the exception being due probably to an unusual distribution of the lymphatic vessels, or to the fact that the carcinoma has wider or deeper relations than are apparent on the surface. Unfortunately, the affected glands speedily acquire intimate relations with the surrounding structures; they lose their mobility, and their removal is thus rendered proportionately difficult. The dissemination of carcinoma of the tongue is comparatively rare, but secondary tumors have been observed in the lungs, the liver, the suprarenal capsules, and, in one instance, in one of the ribs. The infrequency of dissemination may be ascribed partly to a general disinclination of squamous-celled carcinoma to become generalized, partly to the rapidity with which carcinoma of the tongue causes death. Among the cases not submitted to operation, it is rare to meet with one in which life has lasted longer than eighteen months, and a very large number die within twelve months. As death usually results from some cause connected with the horribly advantageous situation of the disease, the carcinoma cannot be supposed to have run its natural course; and it may, on that ground, be assumed that sufficient time has not been allowed for dissemination to occur. Nowhere do the arguments which are employed in favor of early and free operation apply with greater force than in regard to the tongue. For the disease is confined, in the large majority of cases, throughout its whole course, to the tongue and to the neighboring structures and glands. It is thus far a local affection, and if it be treated before it has become a very wide-spread local affection, it may be thoroughly removed.

Experience shows clearly that a certain percentage of patients may be saved by *operation*. Thus, of 70 patients who were subjected to various kinds of operation, and in all of whom the nature of the disease was proved by microscopic examination, 7 are shown by my tables[1] to have been quite well more than seventeen months after the operation, most of the seven several years. One patient died four years afterwards of an entirely different disease, and in one case the tongue again became affected six years after the removal of a carcinoma. I have lately learned that two more of the 70 patients are still alive and well, although several years have elapsed since the operation in each case. The evidence furnished by collected cases further goes to show that life is prolonged by operation, and is made more comfortable even when the disease recurs in the tongue, or when the patient dies from affection of the lymphatic glands.

Carcinoma of the Face.—A great contrast to the carcinomas of the tongue is found in those of the skin of certain parts, and particularly in those of the *skin of the face*. The upper half of the face, especially, is liable to two forms of carcinoma, the squamous-celled and the spheroidal-celled; or, since there is some doubt of the precise relationship of the latter, perhaps it would be more correct to regard it merely as a modification of the former, and to consider all the carcinomatous ulcers of the face as belonging to two varieties of squamous-celled carcinoma, one typical, the other modified. The typical epithelioma commences frequently as a wart or mole, which, spontaneously, or after injury or irritation, enlarges, and then breaks down and ulcerates. The ulcer thus formed bears the characters of an epithelial ulcer, and is recognized by its unhealthy surface, devoid of granulations and often scabbed over, and by the induration of its base and edges, which are often raised, irregularly thickened, and sometimes everted. The disease occurs in men far more frequently than in women; always in adult men, and generally in those advanced in years; but I have once seen it in a man 29 years old. Its course is slow, but it spreads gradually along the surface, and at the same time slowly deepens. It does not tend to affect the lymphatic glands, nor, as far as I am aware, does it become disseminated. But the life history of the disease is but imperfectly known to us, partly perhaps because it has not been deemed sufficiently important or interesting to call for special study and description, partly because so much confusion has reigned, and still reigns, in respect to the relation between this disease and that of which I am about to speak.

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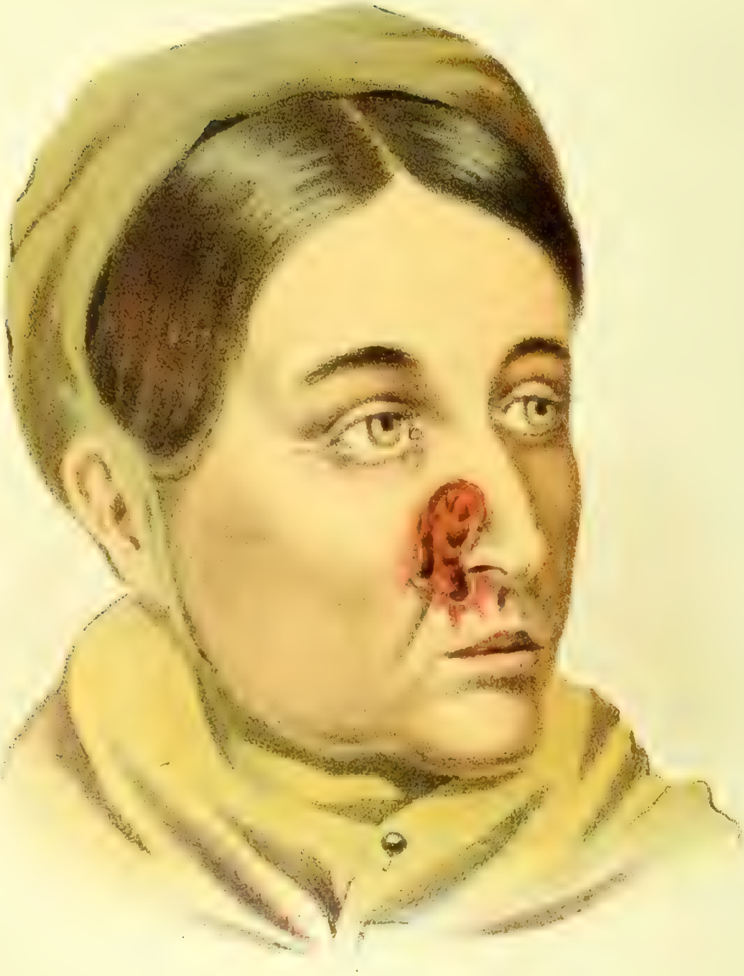
[1] Sarcoma and Carcinoma, p. 156.

PLATE XXV.

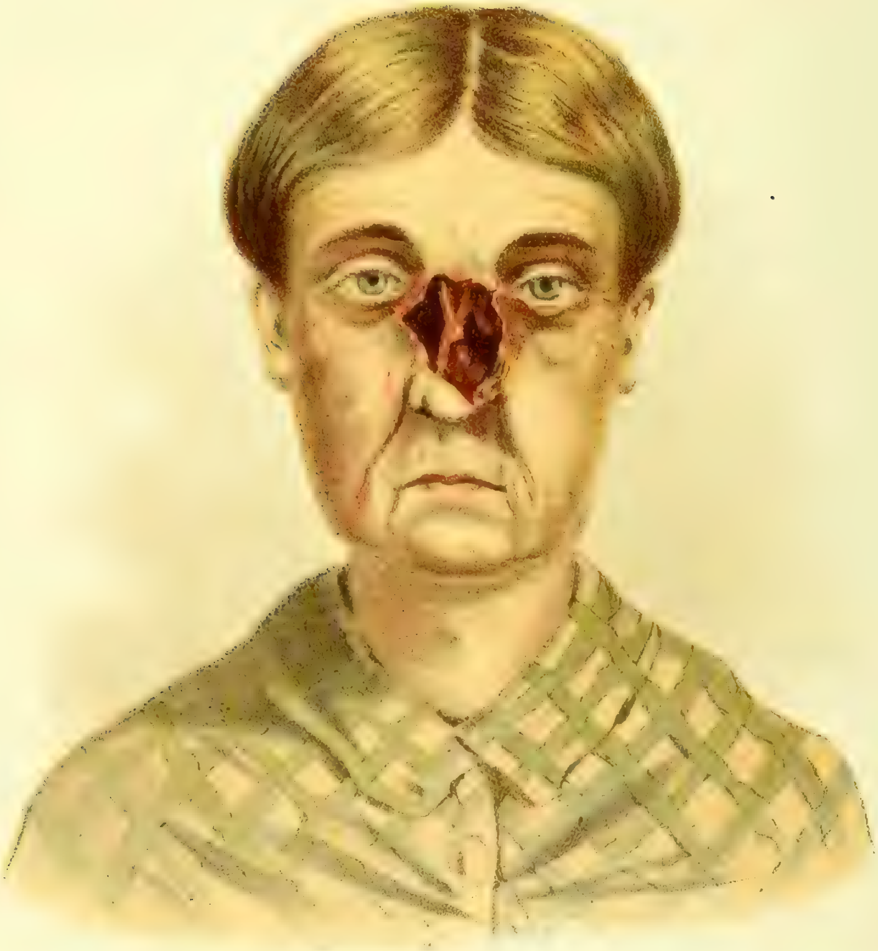


Rodent Ulcer in an early stage.

(From a Patient in the Hospital of the University of Pennsylvania.)

H. BENCKE, LITH N.Y.

PLATE XXVI.



Rodent Ulcer in an advanced stage.

(From a Patient in the Hospital of the University of Pennsylvania.)

H. BENCKE, LITH. N. Y.

The second form is that to which the name "rodent ulcer" has been and still continues to be applied. It has been more studied than epithelioma of the face, but in spite of the attention it has received, was regarded till within the last few years as a disease not truly carcinomatous, but in some indefinite manner related to carcinoma. Dr. Collins Warren[1] was, I believe, the first person to state decidedly that rodent ulcer was a carcinoma; nay more, he regarded rodent ulcer as an epithelioma derived from epidermis, and only differing in a few unimportant respects from the typical examples of epithelioma. During the past six or eight years, the histology and origin of this disease have been made the subject of much study and controversy, and a much clearer knowledge of its histology at least has certainly been gained.

Rodent ulcer attacks especially the parts of the face in the near neighborhood of the eyes and nose. (Plate XXV.) It commences usually as a small sore, or wart, which very slowly ulcerates and very slowly extends. In many cases the disease during this state is treated, and almost invariably by means of caustics, in consequence of which the characters it assumes are modified, if not permanently, at least for a time. The fully developed ulcer, as it appears after a duration of a year or more, presents the following characters: it is superficial, and the surface is often furnished with large, flat granulations which may project above the level of the surrounding skin; the surface is pale-red and glazed, and, if not kept moist with dressing, is generally covered in part or whole with thick scabs; the discharge is purulent and usually abundant; the edges of the sore are in most cases sinuous, a very little raised and uneven, and without the heaping up of tissue which is commonly observed in epithelioma; the surrounding integument is usually normal or but little altered. One important difference which has been pointed out between epithelioma and rodent ulcer is the absence of induration in the latter; but, although induration is not usually as marked or as far spread beyond the edges of the ulcer as in epithelioma, it must not be supposed that it is ever absent; on the contrary, it is in some cases quite as marked in the one disease as in the other. There is another feature often presented by rodent ulcer, which is seldom, if ever, observed in epithelioma; the ulcer may heal in places, with the formation of a thin, pale red or pink, glazed scar. I have from this cause seen a large ulcer divided into two ulcers, separated by a broad band of cicatricial tissue. Whether such ulcers ever completely heal over, and thus become spontaneously cured, I do not know, but am inclined to believe the contrary. On the other hand, there can be no doubt that the disease has a vastly greater tendency to extend, yet with a singularly slow progress. The ulcer will slowly reach the eyelid, and destroy it; then spread along the margin of the orbit and attack the other lid; at the same time, or subsequently, eat into the cavity of the orbit and extend along its walls; then fix, and after a while destroy the eyeball.

Although the ulcer seldom grows much in depth, but creeps, as it were, along the surface, and destroys the skin and subcutaneous tissue, yet it not infrequently exposes and even destroys the surface of the superficially situated bones, the malar prominence, the margins of the orbit, and the nasal bones. (Plate XXVI.) The destruction which ensues from the continued progress of a rodent ulcer is, beyond all conception, horrible. A large portion or the whole of the nose may be removed; both eyes may be destroyed; the middle of the face may be entirely converted into an ulcer which has slowly swept away every feature in its course. Men suffer more frequently from this disease than women, but the difference in this respect is not as notable as in epithelioma of the lip and tongue. Rodent ulcer may commence between the ages of thirty and forty years, but is more often seen in older persons. In both these circumstances it resembles typical epithelioma of the same regions. But a most singular circumstance, in which it differs from malignant disease in general, is the extreme slowness of its course, a slowness not exceptional and belonging only to occasional specimens of the disease, but habitual and almost inseparable from it. Thus, a rodent ulcer will slowly spread during five, ten, fifteen, or even twenty years, produce horrible disfigurement and great destruction, and yet not affect the lymphatic glands nor become disseminated. So uniform is its course in these respects, that the separation which has been till lately made of rodent ulcer from the carcinomas may easily be accounted for. Malignancy of the disease is, however, expressed in its continuous extension, and in the fact that it attacks every structure with which it comes in contact—skin, subcutaneous tissue, fasciæ, muscles, cartilage, and bone.

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[1] Boylston Prize Essay, Boston, 1872.

The *microscopical characters* of typical examples of this disease are these: In the cutis vera and subcutaneous tissue are blocks or irregular masses of cells, closely massed together; the blocks vary much in shape, and are generally much larger than the cell-masses and cylinders of epithelioma. (Plate XXI. Fig. 29.) They are separated by a fibrous tissue infiltrated with small cells, or in some cases are tolerably free from cell-infiltration. The cells of which they are composed are for the most part spheroidal, or angular from mutual pressure, smaller and more uniform in size and shape than the cells of epithelioma, and they contain generally each a single nucleus. (Plate XXI. Fig. 30.) The peripheral layer of cells of each block is more frequently columnar, like the deepest layer of the normal epidermis. In some of the masses or blocks, the cells present another, very different shape. They are elongated, or even oat-shaped, or spindle-shaped, so that a careless examination might lead to the impression that the tumor was a sarcoma. (Plate XXI. Fig. 31.) A closer examination of all parts of the floor of the ulcer will correct this false impression. Occasionally very small and ill-formed cell-nests are observed. The exact origin of the disease has been made the subject of frequent and animated discussions. The deeper layers of the epidermis, the hair-follicles, and the sudoriparous glands, have each been regarded as the source from which the new growth was derived. The balance of opinion inclines towards the Malpighian layer of the cuticle or the hair-follicles; and with this opinion my own accords, on the ground of the similarity of the cells met with in this disease to those of the structures referred to, and of the direct continuity which may sometimes be traced between the cell-masses and those structures. A circumstance may here be mentioned which bears upon the scarring of rodent ulcer, and tends to show that the healing is probably only apparent. In a section cut by Mr. Bowlby perpendicularly through the scarred portion of a rodent ulcer, the characteristic structure of the disease was quite as evident beneath the scar as in the unhealed parts. The disease was therefore not cured, but concealed by the scarring over it. It is not certain that this is invariably the case; a spontaneous cure may in some rare instances be effected, but such healing must always be regarded with suspicion until its completeness and durability have been proved.

The *diagnosis* of rodent ulcer in advanced and well-marked cases presents no difficulty; but in earlier stages, and when the characters are less pronounced, it may be quite impossible to distinguish between this disease and the common form of epithelioma. Practically, the differential diagnosis is not very important, for precisely similar *treatment* should be followed in both diseases. The practice so commonly adopted, of applying caustics to the surface of the ulcer, or of attempting to destroy it with the cautery, is in the very large majority of cases useless, or worse than useless. This treatment, only partially destroying the disease, tends to excite fresh growth, and conduces rather to rapid increase than to cure. Both the facial epithelioma and the rodent ulcer should, whenever it is possible, be very freely removed with the knife, and in the operation every consideration should be banished save the one great consideration of completely removing the disease. If this necessity were borne in mind in the early treatment, especially of rodent ulcer, and the incisions were carried wide of the disease, even to the sacrificing of important and ornamental structures, the success attending the operation would be proportionately increased. Unfortunately, the reluctance of the patient and of the surgeon to sacrifice enough at the first onset, leads generally to insufficient treatment. The disease recurs immediately, and the recurrence is worse than the original ulcer. It is essential to remember that these diseases are strictly local, and that local measures, promptly and widely enough applied, are at once necessary and sufficient for their cure.

Carcinoma of the Larynx.—To compare with the sarcomas of the larynx, and also for the general interest they possess, the carcinomas of the *larynx* may be considered in a few words. Squamous-celled carcinoma is by far the most frequent of them, but glandular-celled carcinoma is not very unusual, and one case at least has been recorded of a columnar-celled carcinoma. The disease may originate in the outer or the inner structures of the larynx: in the epiglottis, the ary-epiglottic folds, or the margin of the interarytenoid fold; in the vocal cords, the ventricles, the ventricular bands, or the subglottic region. To the tumors which arise in the first-named situations, the term extrinsic has been applied; to those which arise within the larynx, the term intrinsic. The distinction is worthy to be borne in mind, on account both of certain differences of symptoms which belong to the two sets of tumors, and of certain important differences in their course. Carcinoma of the larynx is very rare before the age of thirty-five, may occur at any period after, but appears to be most common between fifty and sixty years. It attacks men far more often than women, perhaps four times as frequently. Whatever be the character of the carcinoma, it slowly extends and early ulcerates. Only rarely is a large tumor produced, for the disease, being generally epitheliomatous, exhibits the prevailing features of epithelioma, and is characterized rather by ragged ulceration with an indurated base and edges, than by the formation of a large mass. Like carcinoma of other parts, the disease shows the same disposition to infiltrate, to attack all structures, almost, without choice, and to destroy. The mucous and submucous tissues, the muscles, the essential tissues of the cords and the frame-work of the larynx, all yield to the invading growth.[1] It is most interesting, though painful, to watch the steady progress of a small excrescence or ulcer at first limited to a single cord: how it fixes the cord, then spreads to the ventricle or around to the healthy fellow cord, attacks the deeper structures of the larynx, narrows or fills up the glottis, and at length destroys the form of all the natural structures.

It is not needful or desirable in this place to detail the *symptoms* of the malady: as might be expected, the intrinsic carcinomas produce the earliest and most serious obstacles to respiration; the extrinsic carcinomas are often first noticed on account of pain and difficulty in deglutition, especially when they are seated in the immediate vicinity of the pharynx, about the arytenoids or the ary-epiglottic folds. The *diagnosis* depends upon the presence and extension of ulceration, the greater destruction produced by this disease than even by syphilis or tubercle, the absence of history and of other signs of syphilis, and the absence of the characteristic lesions of tubercle. In doubtful cases, where it is important that a diagnosis should be made, a tiny portion of the growth may be removed with the laryngeal forceps for examination.

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[1] The cartilages, however, resist for a long time the progress of the infiltration.

The disease may prove fatal in the course of a few months, but, in spite of the cruelly advantageous situation of the growth, this rapid course is the exception, not the rule. It is not unusual for a patient, in the absence of any accident, to live for two to three, or even more years. This long duration depends unquestionably on the slow progress of the disease, and the slight tendency to dissemination, while the immediate danger of suffocation is averted by the performance of tracheotomy. In advanced stages of the disease the new growth may perforate the cartilages of the larynx, and form a distinct swelling in the neck. Although the tendency to dissemination appears to be remarkably slight, the cervical lymphatic glands are in many instances affected. Unfortunately, those surgeons who have published cases have not always been sufficiently alive to the importance of noting, or at least of including in their reports, a statement of the condition of the glands. The evidence on this point, therefore, is not nearly as complete as it might easily have been made. But the conclusion which must be drawn from the study of a large number of cases, is that the statement of Krishaber, is, in the main, correct, that the glands are affected by extrinsic, not by intrinsic carcinomas.

Until within the last few years, the *treatment* of carcinoma of the larynx was solely palliative, and consisted of tracheotomy and the use of soothing local remedies. But, lately, removal of the disease by extirpation of the whole, or part, of the larynx has been practised. A large number of cases of this operation were collected by the late Dr. Foulis, who laid before the London meeting of the International Congress, in 1881,[1] a table of cases of extirpation of the larynx, twenty-five of which were for carcinoma.[2] The results of the operation are not sufficiently satisfactory to encourage surgeons to continue its performance. All the patients died save two or three—within a few months from recurrence of the disease, or within a few days from the immediate results of the operation. Of the three patients who did not die from either of these causes, the periods through which they had respectively been watched were seven months, four months, and about three months. Nevertheless, it is quite possible that earlier operation and a more careful selection of cases, with special reference to the intrinsic origin of the tumor, may yield a very different result, and that the operation, thus limited, may become justly popular. [Of 56 operations for carcinoma, tabulated by Dr. J. Solis Cohen,[3] 40 proved fatal, and more than half of these within the first fortnight. In only 6 cases were the patients known to be alive a year after the operation.]

The foregoing examples will serve to show that carcinoma, like sarcoma, is influenced largely by the nature and relations of the part in which it takes its origin—even more, probably, than by any other single condition. They prove that the course and duration of the disease are largely influenced by its origin; that dissemination depends, probably, in great part on the origin of the tumor; and, above all, that the affection of lymphatic glands depends, not on the structure of the tumor, as was formerly taught, but on the circumstance that a tumor of a certain structure has been developed in a certain part. How largely these considerations must in future influence the prognosis and treatment of malignant tumors, needs scarcely to be stated.

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[1] Transactions, vol. iii. p. 255.

[2] Dr. Burow has collected a still larger number of cases in the Archives of Laryngology, 1883.

[3] Trans. Coll. Phys. Phila., 3d s., vol. vi. p. 353.

CYSTS OR CYSTIC TUMORS.

Nature and Pathology of Cysts.

A cyst may be defined as a sac with liquid or solid contents. The term may be restricted by applying it only to those sacs which are lined with epithelium or endothelium, or it may be much more widely extended by including among the cysts all collections of liquid lying in the midst of solid tissues, whether they are inclosed in a distinct sac or not. The word is employed here in its more restricted sense, while to those liquid collections which are not inclosed in sacs, and which commonly owe their origin to softening or liquefaction of solid tissues, the tissues of a tumor for example, the term *cystoid* is applied.

All cysts, in regard to their pathology, may be gathered into three groups: I. Those formed by the distension of previously existing sacs or tubes; II. Those of new formation; III. Those of uncertain origin.

I. Cysts formed by Distension of previously existing Sacs or Tubes.

Retention-Cysts.—The first class includes the *retention-cysts*, of which excellent examples are found in the sebaceous, the mucous, and the milk cysts. All these are formed by the distension of the glandular sacs or ducts of the sebaceous, mucous, and mammary glands. They owe their origin always to the occlusion of the ducts of the various glands, while the secreting structures still continue to perform their functions. The ducts may be partially or wholly closed by many different causes, among which may be mentioned, as the most frequently observed, the pressure of tumors or inflammatory swellings, cicatrization, the formation of tumors within the ducts, and the inspissation and concretion of certain discharges at the mouths of ducts. Although the contents of these cysts usually resemble the secretion of the gland in which they have been formed, this is by no means invariably the case. The quality of the secretion may be altered, and, especially in the case of cysts which partially discharge their contents, either constantly or at frequent intervals, the character of the contents may undergo great modification. For milk or mucus, may, in this manner, be substituted a thin serous fluid. Blood, too, may be extravasated into the interior of a cyst of whatever kind. The walls of the retention-cysts are composed of fibrous tissue—close-textured and tough around the larger and older cysts, hardly amounting to more than a homogeneous membrane in the smallest and most recent cysts—lined with one or more layers of epithelial cells. Between the fibrous tissue and the epithelium can sometimes be detected an endothelial layer, particularly in those cases in which proliferation of the endothelium has taken place, and in which a tolerably thick intervening membrane has been formed. The epithelium may closely resemble that which previously lined the cavity, or may be modified in shape, and may form several layers in place of a single layer.

A retention-cyst may be formed by the distension of a single duct, whether large or small. It may also be formed by the distension of a single acinus, but is much more commonly developed by the distension of a group of acini. Each acinus of the group, at or about the same period, becomes dilated; as the dilatation advances, a sacculated cavity is formed, the interior of which is partly divided by the partition walls between the acini; with the still greater increase of the cavity the partition walls gradually disappear, and the cavity tends to assume a spherical shape.

EXUDATION-CYSTS.—To the first class belong also the *exudation-cysts*, of which the enlargements of bursæ, hydrocele, and many of the cysts of the thyroid body and of the ovary, may be taken as examples. The cavities out of which the bursal and serous cysts are formed, contain for the most part only a sufficient quantity of fluid to lubricate them, and to diminish, as far as possible, the friction attendant on the gliding of their walls upon each other. From some cause, perhaps slight inflammation, or merely irritation, an increased quantity of fluid is poured out, and the cavity becomes a cyst. It is not certain that all bursal cysts are formed by the dilatation of previously existing bursæ, for the bursa itself may be a new-formed cavity and not a natural sac. The development of such a cavity will be presently considered. Nor has the hydrocele any other than a prescriptive right to be regarded as a cyst, for collections of fluid in other serous cavities, the pleura and the peritoneum, for example, are not numbered among the cysts. Certain of the cysts of the thyroid body are not improbably formed by the pouring out of fluid into the sacs of the gland, but others of them are more probably due to colloid changes in the cells which the sacs contain. The thyroid cysts are lined usually with a layer of spheroidal cells, but the hydrocele and bursal sacs only with endothelium. The fluid which these various exudation-cysts contain varies with the origin of the cysts. It may be thick and clear like synovia, or clear and thin like serum, or blood-stained, or wholly blood. But, besides liquid, some of these cysts contain solid bodies. Thus, the distended synovial sac beneath the annular ligament of the wrist contains flattened bodies resembling melon seeds, formed either by changes in fibrine or by the growth and organization of club-shaped extremities of fringes formed within the sac. They are either amorphous or bear the trace of a low organization. The well-known ganglia on the back of the wrist and on the dorsum of the foot, are probably formed by a modification of the distension process. For they appear to be in the first place pouches derived from the synovial sheath of a tendon; the pouch is by and by cut off from the sheath, and then forms a separate sac or cyst. The contents of ganglia differ from the contents of most of the other exudation-cysts, in being much more viscid. Indeed, they are jelly-like, clear, colorless or faintly yellow, and quite coherent. The material resembles in some respects colloid material; it does not contain albumen.

It must not be forgotten that some of the exudation-cysts may be due to a faulty process of absorption, rather than to the pouring into the cavity of an abnormal quantity of fluid.

BLOOD-CYSTS AND LYMPH-CYSTS.—Still to the first class belong the cysts which are formed in connection with bloodvessels or lymphatics. Their development appears to resemble in some respects the development of ganglia from synovial membranes. A sac-like pouch is protruded from a vein, in most instances a varicose vein, and by and by the connection of pouch with vein is severed. In other instances the lumen of a vessel, whether vein or lymphatic, is occluded at two or more points, and between these points is patent; thus one or several cysts are formed. In this way are developed certain of the blood-cysts and lymph-cysts. Yet even these cysts do not always contain blood or lymph: a serous fluid may be substituted for either. The walls of blood-cysts and lymph-cysts may be quite smooth, and lined with endothelium, or may be roughened from the presence of vascular fringes and excrescences.

Some of the cysts which are formed in cavities due to arrests of development must also properly be reckoned among the exudation-cysts; those, for example, which are formed in the processus vaginalis of the spermatic cord, in the Wolffian body, and in the ligamentum latum.

II. Cysts of New Formation.

Extravasation-Cysts.—The second class of cysts, those of new formation, includes several varieties. First, are the *extravasation-cysts*, formed by changes in and around a blood-extravasation. The surrounding tissues become condensed, and connective tissue is developed, in some instances certainly as the product of inflammation, but not always of inflammatory origin. The inner surface of the cyst-wall may be lined with endothelium. The blood may be absorbed and replaced by serous fluid; or it may be changed, as in coagulation, the wall of the cavity being roughly lined with clot and the expressed serum occupying the centre. The serum may contain blood-crystals and pigment-molecules.

In the same way in which an extravasation becomes inclosed within a cyst-wall, a foreign body may acquire a sac and become the solid contents of a cyst.

Parasitic Cysts.—To the cysts of new formation belong the sacs which are formed in connection with parasites: echinococcus, cysticercus cellulosæ, and others.

Cysts formed in Areolar Tissue.—It appears probable that some cysts are formed by the expansion of areolar spaces of connective tissue. A number of adjoining spaces thus expanded and fused together by the absorption or attenuation of the intervening tissue, form a cavity sometimes of considerable size. The immediately surrounding tissue is condensed, and forms a fibrous wall which may be even lined with endothelium. The contents of such a cyst are generally clear, serous fluid. Many of the adventitious bursæ are attributed to this cause. Even the bursa over the patella is often regarded as an adventitious bursa formed in this fashion, and the bands which are sometimes found crossing its interior are thought to be the remains of fibrous partitions which formerly separated the areolæ from which the bursa was developed.

Some of the congenital cystic tumors, the cystic hygromas, are thought to be developed by the expansion and fusion of areolar spaces, but others of them have been traced to a connection with lymphatic vessels, and a few are supposed to be developed in connection with the remains of fœtal structures.

Cysts formed by union of Papillary Processes.—Another method by which cysts are newly formed is by the growing together of certain portions of adjacent papillary processes, while other portions of them are separated by fluid. Such cysts are developed more commonly in connection with tumors than in the natural textures. They are lined with the same variety of epithelium as that which covers the papillæ, generally columnar.

Cysts from Changes in Cells.—Last of the cysts of new formation, but certainly not least, for they are more truly wholly of new formation than some of those which have been described, are the cysts which are due to changes in cells. By proliferation a group of cells is produced, of which the outer form a capsule, and those which lie next a cellular lining for the capsule, while those in the interior, undergoing a liquid transformation, form the contents of the cyst. Or, the cyst-wall may be formed by condensation of the surrounding tissues; the lining and contents by changes in the cells. Certain of the cysts in the ovary, the kidney, the thyroid, and other organs, and many of the cysts in tumors, are probably thus derived from changes in cells, either connective-tissue or epithelial.

III. Cysts of Uncertain Origin.

The cysts of uncertain origin include some of the congenital cysts and cystic tumors, some of the dermoid cysts, and some of the anomalous mucous sacs and bursæ. The origin of some of the congenital cysts has already been traced; others of them are derived from changes in meningoceles, whether of the brain or of the cord, owing to which the communication between the sac and the arachnoid has been obliterated. But the origin of others cannot so certainly be discovered: they are, therefore, classed among the cysts of doubtful origin. Again, certain of the dermoid tumors are unquestionably developed in unclosed or only partially obliterated embryonal clefts, as in the branchial fissures. Thus they occur in the sides of the neck or behind the sternum, and their presence is not necessarily observed during infancy or childhood. An accidental circumstance may cause the tiny cavity to enlarge, until it may reach a considerable size, and, being inflamed, may open or perhaps be opened. The interior of such a cyst is generally quite smooth and lined with epithelium in layers, resembling the epithelium of the skin. The contents are, for the most part, soft-solid, resembling in appearance the contents of a sebaceous cyst, and consisting of epithelial scales which have been cast off from the lining of the wall. In addition to this substance there are frequently hairs, and, less commonly, solid masses covered with skin and furnished with hairs, and with sebaceous and even sudoriparous glands. Some of the dermoid cysts contain teeth, or fragments of cartilage or bone. It is thought that most, if not all, of the dermoid cysts are formed by arrests and modifications of development. They are found in many different parts of the body—in the skin and subcutaneous tissue (especially of the temporal and orbital regions), in the testis and ovary, uterus, brain, pleuræ, lungs, and mesentery, and in the neck and anterior mediastinum.

Relations of Cysts to Solid Tumors.

Before proceeding to discuss the general characters and treatment of any of the special forms of cyst, it will be well to advert for a moment to the relations between cysts and solid tumors. But first, the combinations of cysts with other cysts must be referred to. Several or many cysts may be developed in one or other of the ways which have been described, and, lying close together, may constitute a compound cystic growth. Or, cysts may be formed within a cyst, which, until it be opened, bears the appearance of a simple cyst. These intracystic or secondary cysts are not necessarily developed in the same fashion as the mother cyst; for, while the latter may be the result of distension of a previously existing cavity or sac, the former may be due to the inclusion of spaces between papillary growths from the inner surface of the wall of the mother cyst, or to transformation of cells or groups of cells. Large cysts with intracystic cysts are not uncommon in the ovary. By similar processes to those by which the secondary cysts are formed, tertiary cysts, or cysts within the secondary cysts, may be developed.

A solid tumor may be formed within a cyst by outgrowth, or rather ingrowth, of its walls. Such growths are often papillary, derived from the epithelial lining of the sac; or the connective tissue, either of the sac itself or of the parts immediately beyond the sac, may commence to grow unduly, and, experiencing least resistance in the direction of the cyst, may intrude upon its cavity, thrusting before it the lining membrane of the cyst. The papillary growths may be met with in such simple cysts as the sebaceous, and may in time entirely occupy the sac to the exclusion of the material which previously filled it. The second form of intracystic growth is much more frequently observed in tumors partly cystic and partly solid, those of the mammary gland for instance (sero-cystic disease), in which the cysts are often occupied by connective-tissue growth, rarely by epithelial.

Cysts may develop within a solid tumor by almost any of the methods which have been described. Thus, they may be formed from previously existing ducts and acini, as in the cystic tumors of the breast; or by the growing together of papillary processes, as in tumors of the breast and ovary; or by condensation around blood or other morbid material; or by the expansion and fusion of the areolæ of connective tissue; or by changes in cells, or groups of cells. Many of the cavities which are found in tumors are produced by liquefaction of some of the solid structures of the tumor, and are rather cystoid than cystic. Some of the cystoid cavities are furnished with perfectly smooth walls or sacs, but many of them are irregularly shaped spaces with ragged walls. Every kind and degree of cystoid cavity may be observed in soft, sarcomatous tumors, or, better still, in large tumors partly chondrified. The cartilage of such tumors often softens down into a clear viscid fluid, which forms the contents of the cystic cavity.

The cysts in solid tumors may be again filled up in whole or part by intracystic growths, in or about which a second series of cysts may be formed. By a succession of such changes are produced the singular characters presented by certain of the cystic tumors of the breast.

SPECIAL VARIETIES OF CYST.

Most of the cysts will be described in other parts of this work, in the sections devoted to the diseases of the organs in which they commonly occur—the breast, the ovary, etc.—but some of them may be more fitly considered in this place.

SEBACEOUS CYSTS.—These may occur in any part of the body in which sebaceous glands naturally exist, but are more frequently found in the scalp than elsewhere. Several of them may be found in the same patient. They are far more common in adults than in children. The characters they present are generally very decided: a rounded or oval shape; a soft, sometimes fluctuating, sometimes doughy consistence; an indolent course. They are seated chiefly in the subcutaneous tissue, but are attached so closely to the skin that they cannot be separated from it. The skin covering them is sometimes unchanged, but, in the scalp, is generally smooth, and bald, and white, and in other parts, when the cyst is large, is often reddened, and marked by ramifying vessels; on the summit of many of the cysts may be found a tiny depression marked by a dark speck, corresponding with the obstructed duct of the gland from which the cyst has been developed. If not interfered with, they may remain during many years unaltered, neither increasing nor diminishing in size, or they may slowly increase and attain the size of an ordinary orange, but seldom a larger bulk than this. Their characters are, however, subject to modification from several different causes. The contents of the cyst, which usually form a soft, semi-solid, whitish, paste-like or grumous material, often very offensive, may become calcified, and the cyst may acquire a stony hardness and an irregular outline; or, the normal contents may be replaced by a solid growth from the lining membrane of the cyst; or, and this is far more common, the cyst may become inflamed. The surface and the surrounding parts become red, and the local signs of inflammation are complete. Suppuration may take place, and, the cyst being opened and the pus discharged, a cure may be effected. Even sloughing may occur from the severity of the inflammation. Suppuration does not necessarily end in cure of the disease. An intractable ulcer may remain after the destruction of the cyst, and, with its unhealthy-looking surface and raised everted edges, may resemble a malignant ulcer.

The *diagnosis* of a sebaceous cyst, as may be gathered from the description of its character, is generally very easy. The only diseases for which it is likely to be mistaken are a fatty tumor and a chronic abscess. The former is easily recognized by the firmer feel, the presence of lobes, and the more flattened shape; the latter by the more distinct fluctuation, the less rounded shape, and less mobility of the tumor. Even a dermoid cyst, closely related as it is to a sebaceous cyst, and closely as it resembles it in some respects, may usually be distinguished without difficulty by its situation in one of the seats of election of dermoid cysts, the temporal or orbital regions, and by the early age of the patients who are subject to it. An inflamed sebaceous cyst may, in most instances, be diagnosed by the presence of a definite tumor in the centre of the inflamed area, and by the intensity of the inflammation. And an ulcerated cyst, which looks like a malignant ulcer, may be known for what it is by the history of the case, the absence of deep-seated infiltration, and the character of a scraping of the surface of the ulcer, examined microscopically.

The *treatment* of sebaceous cysts may be by several different methods. When they produce no inconvenience, and are not so placed that they are unsightly, they may be left untouched; and, provided that they are not irritated, may remain without change during many years. The small sebaceous tumors of the scalp, especially when there are several of them, are often left untreated for long periods of years, and would be left still longer were it not that, when they have attained a certain size, though still small, they are liable to be caught and torn by the comb. Small cysts may be cured by the application of the strongest nitric acid, or some other caustic, which may require to be applied on two or more occasions before complete destruction or removal of the cyst is accomplished. Caustics are, however, recommended only for those cases in which, either on the part of the patient or the surgeon, there is a special objection to the use of the knife. Some of the smaller sebaceous cysts may be cured by the following simple means. The tiny central depression which marks the exit of the obstructed duct on the summit of the tumor, having been found, is opened and distended rapidly by the introduction of probes, until it is sufficiently large to allow the thick white contents of the sac to be squeezed out. If this be thoroughly performed, and the surfaces of the sac be rubbed together, the latter may shrivel, and not refill.

For the large majority of cases, removal with the knife is the proper treatment. The cyst may be dissected out through a simple incision; but, since it often adheres closely to the surrounding tissues, the safest general rules to be observed in the removal are, freely to open the cyst—by transfixion, if it be large—turn out its contents, seize the floor of the sac with a pair of toothed forceps, and drag it out. Ulcerated cysts generally require removal. Sebaceous cysts should never be removed at the time when they are inflamed, however urgent the desire may be for their removal. The operation should always be deferred until the inflammation has subsided.

DERMOID CYSTS.—These are almost always, if not always, congenital. The simplest varieties are situated beneath the outer corner of the eyebrow. The tumor is generally noticed during infancy or childhood as a small, round, or oval body, no larger than a pea or horse-bean. It lies beneath the fascia, and is tolerably freely movable, while the skin over it is normal. The contents are almost invariably fine hairs embedded in a thick, sebaceous-looking mass, composed of epithelial cells and fatty matter. Removal is effected through a simple incision in the line of the eyebrow. The cyst, in spite of its apparent mobility, is generally closely adherent to the surrounding textures, and, on account of the thinness of its wall, can only be dissected out unbroken by observing the greatest delicacy in the performance of the operation. The edges of the wound are brought together with fine horsehair or thread sutures, and a scarcely perceptible scar remains.

The dermoid cysts which are met with beneath the tongue, in the neck, and in the anterior mediastinum, are apparently formed in connection with imperfectly closed branchial fissures. They are generally of much larger size than those last described, and their contents are much more complex. From such a cyst I have seen removed large masses of irregular shape, covered with skin and hairs. When sections were made of them, they were found to be composed of fibrous and adipose tissues, in which were numerous sebaceous and a few sudoriparous glands. The masses were embedded in a large quantity of pultaceous material, composed chiefly of epithelial scales, which had been cast off by the skin covering the masses and lining the cavity. These cysts may be mistaken for chronic abscesses, all the signs of which they may present, and may, therefore, be opened in the expectation of evacuating a quantity of pus. They are much more difficult to treat than the smaller cysts on account of the depth at which they are situated, and the important structures by which they are surrounded. When they cannot be removed, the better plan of treating them is to incise the tumor, completely clear out its contents, and cauterize or thoroughly scrape the surface of the sac, which may then be left to heal up from the bottom like an abscess-cavity.

Dermoid cysts are also found in the testicle and scrotum, the ovary, the brain, and the lung. Their contents are sometimes very complex: in addition to hairs, skin, and glands, they contain bone, cartilage, teeth, and other structures.

SANGUINEOUS CYSTS.—Of late years much light has been thrown on the pathology of sanguineous cysts by the discovery that many of them are sarcomas, into which hemorrhage has taken place. The knowledge of this fact has, perhaps, led surgeons to take too gloomy a view of the future of almost every blood-cyst which they are called upon to treat. Sarcomas of this kind have been alluded to in the section on sarcoma, under the heading "hemorrhagic sarcoma." They may be found in various tissues and organs, and are almost invariably of the round-celled or spindle-celled variety. They are recognized generally by their rapid growth, and, when cut into, by the irregularity and roughness of their walls, and by the presence here and there of tiny fragments of a soft solid mingled with the blood. Microscopic examination of fragments taken from the roughened walls betrays the real character of the disease; and the sarcoma-tissue, as Mr. Godlee has shown,[1] may even be traced as a kind of meshwork through the substance of the hardened blood-clot.

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[1] Transactions of the Pathological Society, vol. xxvii. page 270. London, 1876.

The identity of these blood-filled and transformed sarcomas should be established as early as possible, for the prognosis and treatment must be guided by the recognition that the disease has all the gravity of an ordinary sarcoma of the part affected. Fortunately, however, all blood-cysts are not masked sarcomas. Some of them are serous cysts, in which the serum has been replaced by blood, or has been largely mixed with blood: this transformation is occasionally seen in hæmatoceles which are formed from hydroceles. Some of them are developed in connection with bloodvessels in the manner already described on a preceding page. Some of them are of uncertain origin. They may occur in different parts of the body, and have been met with in the neck, the thigh, the parotid gland, the thyroid body, and the trunk. Most of the blood-cysts of the parotid and the thyroid are probably examples of cysts of other kinds into which hemorrhage has taken place. Those of the neck appear to be the most frequent. They vary in size and outward characters, but are seldom very large. The blood which they contain is almost all, and always, fluid; but, while the tumor is, in most instances, undoubtedly cystic, the nature of its contents is usually not recognized until it has been punctured. The interior of the sac is generally quite smooth, but may be columnar or fasciculated like the interior of the auricles of the heart. These cysts may be tapped, and the blood evacuated, and this may suffice for cure. But they almost always fill again, sometimes indeed immediately, and render further treatment necessary. The treatment suitable, in such cases, is to lay the cavity completely open, clear it of its contents, and plug it from the bottom with strips of lint. If there be hemorrhage into the cyst at the time of operation, the bleeding vessels should be sought for and tied: if the hemorrhage be capillary or venous, it will be arrested by the lint plugs.

Mucous Cysts.—Of these the best examples may be found in the cysts at the neck of the uterus, in the labia, in the lip, beneath the tongue, and in the antrum. The first of these are formed in connection with the glands of Naboth: they often burst and discharge their contents, and are then re-formed or are replaced by others of a similar kind. The second are formed by dilatation of Cowper's or Duvernoy's glands. They are seldom multiple, like those of the uterus, but attain a larger size.

The mucous cysts of the lip are, I think, less common than those of the uterus and vulva. They are developed usually on the inside of the lower lip, not far from the prolabium, by dilatation of the submucous glands. They are easily recognized by their smoothness, their rounded or oval shape, and their translucence, which is very obvious. I have never seen one larger than a common nut.

Of far more frequent occurrence are the mucous cysts in the floor of the mouth, beneath the tongue, which are known under the name "ranula." A few of them are, perhaps, developed by a dilatation of the duct of the submaxillary gland, but the large majority of them probably originate in the mucous glands beneath the tongue. The tumor may be much larger than in the last case, and may contain from half an ounce to an ounce of fluid. It is quite easily recognized by its situation, its bluish color, its consistence, and its translucence. Cystic disease of the antrum is not very common. The cavity is seldom distended by a single cyst, but contains several or many cysts which may in time distend it to the utmost. All these cysts contain, in most instances, a glairy, clear, whitish, or yellowish fluid, not unlike white of egg. But the contents are not, in every case, so clear and almost colorless. They are occasionally, especially in the tumors of the labium, opaque and dark colored, and sometimes very thick. The *treatment*, for those of the labium, the lip, and the floor of the mouth, is to open the cyst freely, squeeze out the contents, and apply solid nitrate of silver, or some similar caustic, to the inner surface of the sac. Even after this severe treatment the cyst sometimes fills again, and requires a repetition of the process, or the introduction of a seton. Removal of the cyst cannot be recommended on account of the difficulty of dissecting the whole of it away, for it is often thin-walled and very adherent to the surrounding structures, while its situation and the hemorrhage which invariably occurs render it, in the case of cysts of the mouth and labium, exceedingly difficult to complete the operation successfully.

SEROUS CYSTS.—The best examples of *serous cysts* are met with in the congenital cystic tumors of the neck, to which the name cystic hygroma has been given. They sometimes form large and single cysts, smooth-walled, thin-walled, and containing a clear, thin fluid, in most instances colorless; but, more often, a cystic tumor is observed, formed of an irregular mass of connective tissue, in which are several cysts, neither of them, perhaps, of larger size than a common nut or small walnut. The outline of such a tumor is usually ill-defined, and, if an attempt be made to dissect it out, it is found exceedingly difficult, or even impossible, to distinguish the exact limit of the growth. Some of these cysts are probably formed by distension and fusion of areolar spaces of the connective tissue; but, since most, if not all, of them are lined with endothelium, it is thought that they are developed rather by distension of lymphatic spaces than of mere areolar spaces in the tissue. As many of the spaces, formerly regarded merely as areolar, are now known to be lymphatic spaces, the difference in origin assigned to these congenital cysts is rather apparent than real; it is not that they arise by the distension of a different set of spaces, but that we know better the nature of the spaces which, distended, form the cysts. The occurrence of congenital hygroma, though far more frequent in the neck than elsewhere, is, by no means, limited to the neck. I have seen a simple cyst of this kind in front of the sternum, and another precisely similar in the axilla, and large cystic tumors, such as are described above, in the arm and thigh. Nor, although these tumors are probably all congenital, are they always first observed during infancy, or even childhood.

The large single cysts are best *treated* by puncturing and injecting them with tincture of iodine as a common hydrocele is treated; or a seton may be passed through the cyst and left in till sufficient inflammation has been excited. This method is not, however, free from danger, even fatal inflammation having been excited by the presence of the thread. The cystic tumors are very troublesome to treat. The individual cysts which they contain may be treated like simple cysts; but the surrounding connective tissue, if it be not growing, may be more safely left than meddled with. If it be increasing, it is generally best to try and remove it in spite of the difficulties arising from its diffused character. I have myself seen death result from the passage of setons through such a tumor, three days after their introduction. The presence of the setons set up a violent general inflammation of the tumor, associated with grave constitutional symptoms, to which the patient, a young child, speedily succumbed.

Serous cysts are frequently met with in the breast, less often in the testicle. In the testicle they almost invariably occur as cysts in tumors, and are formed by dilatation of the glandular structures of the organ. In the mamma, although many of the cysts also occur in combination with solid tumors, and are almost always developed from the glandular structures, yet simple cysts, independent of any solid growth, are of tolerably frequent occurrence. Some of these cysts are also developed by distension of the ducts and acini of the gland, and are lined with one or more layers of epithelium; but others of them are formed by distension of lymphatic spaces in the connective tissue of the breast, and are lined with endothelium. Such cysts may be single or multiple, and, in the latter case, may lie in different portions of the breast, or may be clustered together to form a single lobular tumor, the nature of which may not be recognized until it has been cut into, perhaps on the supposition that it is cancerous, for the cysts, being small, are not readily discovered. These clustered cystic tumors are best treated by removal of the mass composed of cysts and indurated fibrous tissue, in the midst of which they lie. The simple, single cysts can generally be obliterated by opening and plugging them with lint.

Many of the large cystic tumors of the ovary are examples of serous cysts, and among other serous cysts must not be forgotten hydroceles, whether of the tunica vaginalis or of the cord.

DESCRIPTION OF PLATES ILLUSTRATING THE MICROSCOPIC APPEARANCES OF TUMORS.

PLATE XVIII.

Fig. 1. Lipoma of Shoulder, × 60.
Fig. 2. Fibroma of Breast, × 260.
Fig. 3. Myxoma of Lower Jaw, × 260.
Fig. 4. Columnar-celled Adenoma (Polypus of Rectum), × 40.
Fig. 5. Papilloma of Vocal Cord, complete section, magnified about 8 times.
Fig. 6. Myoma of Uterus (Leiomyoma), × 260.
Fig. 7. Round-celled Sarcoma of Thigh, × 260.
Fig. 8. Spindle-celled Sarcoma over Pubes, × 260.
Fig. 9. Giant-celled (Myeloid) Sarcoma of Ulna, × 260.

PLATE XIX.

Fig. 10. Glioma of the Eye, × 200.
Fig. 11. Mixed-celled Sarcoma of Femur, × 260.
Fig. 12. Trabecula of an Ossifying Sarcoma of the Ilium, × 260.
Fig. 13. Chondrifying Sarcoma of Submaxillary Gland, × 260.
Fig. 14. Fibrifying Sarcoma of Gluteal Region; drawing from a portion of the tumor which was completely fibrified, × 40.
Fig. 15. Spheroidal-celled Carcinoma of Breast (hard), × 280.
Fig. 16. Spheroidal-celled Carcinoma of Parotid Gland (soft), × 40.

PLATE XX.

Fig. 17. Squamous-celled Carcinoma of Leg (Epithelioma); vertical section, magnified about 8 times, to show the epithelial masses dipping down into the subjacent tissues.
Fig. 18. Squamous-celled Carcinoma (Epithelioma) of the Tongue, showing cell-nests, × 200.
Fig. 19. Columnar-celled or Cylindrical-celled Carcinoma of Rectum (after Cripps), × 60.
Fig. 20. Round-celled Sarcoma (Lympho-sarcoma) of the Tonsil, × 260.
Fig. 21. Alveolar Sarcoma (containing a few Giant-cells) of Thumb, × 60.
Fig. 22. Round-celled Sarcoma (Cylindroma) of Popliteal Space, × 90.
Fig. 23. Portion of the same growth more highly magnified, × 260.

PLATE XXI.

Fig. 24. Myxo-sarcoma of Breast, showing the cells between the adipose cells, beyond the apparent margin, × 90.
Fig. 25. Racemose Adenoma of Breast, × 40.
Fig. 26. Colloid Carcinoma of Pylorus, × 260.
Fig. 27. Transverse section of "Eczematous Nipple," associated with carcinoma of breast, showing diseased condition of many of the ducts, × about 8.
Fig. 28. Altered Epithelium of Galactophorous Ducts from "Eczematous Nipple," × 260.
Fig. 29. Rodent Ulcer of Face, × 40. The white areas represent masses of epithelium dipping into the adjacent parts.
Figs. 30, 31. Rodent Ulcer of Face, × 200.

INJURIES OF THE BACK,

INCLUDING THOSE OF THE SPINAL COLUMN, SPINAL MEMBRANES, AND SPINAL CORD.

BY

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THE region whose injuries are to be considered in this article, embraces the posterior part of the neck, chest, abdomen, and pelvis, or, in other words, the posterior part of the whole trunk excepting the head. The organs contained in this region are, (1) the spinal cord, with the spinal meninges and the roots of the spinal nerves; (2) the vertebral column, from atlas to tip of coccyx inclusive; and (3) the muscles both great and small which are attached to the vertebræ, together with the integuments that cover them.

The welfare of these organs is a subject of extremely great importance, inasmuch as their integrity, considering them as a unit, is essential to the very existence of man as an animal. I cannot emphasize this point in any better way than by calling attention to the fact that the vertebral column is the first portion of the skeleton to appear in man, and the centre around which all other parts of the skeleton are produced; that the spinal cord is the first formed portion of the nervous system, and the centre to which all other parts of the nervous system are appended; and that the chorda dorsalis of the embryo "forms the basis around which the vertebral column is developed." At first, the vertebral column is a simple cartilaginous tube which surrounds and protects the primitive trace of the nervous system in the embryo; but, as it advances in growth and organization, it becomes divided into 33 distinct pieces constituting the vertebræ; of which 24 are called true and 9 false. At a still later period, the false vertebræ coalesce, the upper 5 of them to form the sacrum, and the lower 4 to constitute the coccyx, the process of coalescence being completed at maturity or the termination of growth. The true vertebræ, however, do not coalesce; but, placed one above the other, they constitute a flexible tubular column, composed of ring-shaped bones alternating with lenticular disks of firm yet elastic intervertebral substance, and bound together by broad, thin planes or bands of ligamentous tissue, many of which are also elastic. The vertebral tube is lined by the spinal dura mater, or theca vertebralis, which is continuous with the cerebral dura mater above it, and contains much cerebro-spinal fluid in which the spinal cord, attended by large plexuses of veins, hangs suspended from the base of the brain by its attachments to the pons Varolii, as it were, in a well. The cerebro-spinal or sub-arachnoidean fluid also keeps up a constant and gentle pressure upon the entire surface of the spinal cord as well as upon that of the brain, and yields with the greatest facility to the various movements of the spinal cord and spinal column, giving at the same time to the delicate structures of the cord and brain the advantages of the mechanical principles so usefully applied by Dr. Arnott in the hydrostatic bed. Thus we find that the spinal cord is protected in a truly wonderful manner from the ill effects of blows, and shocks, and pressure, by an elastic, fluid medium which everywhere surrounds and gently compresses it.

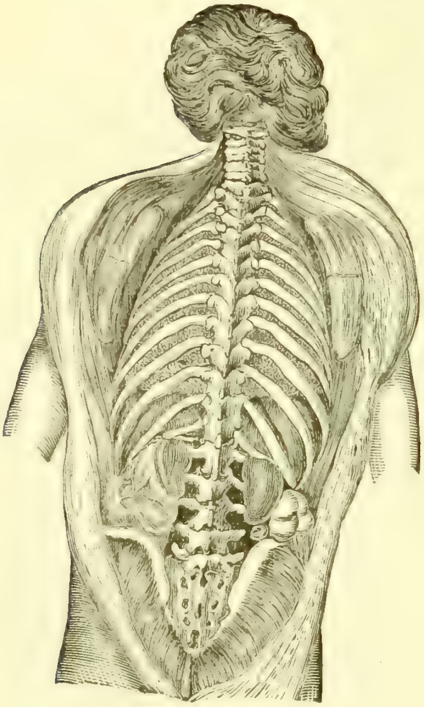
The traumatic lesions of the back naturally arrange themselves in three groups, as follows:—

I. Injuries of the integuments and muscles, or soft parts generally.
II. Injuries of the vertebral column.
III. Injuries of the spinal membranes, spinal cord, and spinal nerves.

For the purposes of study and description, this classification of the traumatic lesions to which the dorsum of the trunk is exposed presents some advantages which are quite obvious, and, therefore, I shall follow it as far as may be found serviceable. It should be borne in mind, however, that the examples which claim the surgeon's attention in practice usually illustrate at least two of these forms of injury; and that, not unfrequently, all three are simultaneously exhibited in the same patient. The symptoms and treatment of these lesions must therefore be described from general or common, as well as from specific points of view.

From most writers on surgery, injuries of the back have not received that degree of attention which their importance justly demands. This neglect may have arisen on the one hand from undervaluing the functions of the spinal cord itself, and holding it to be merely an appendage of the brain, or, on the other hand, from considering the injuries which involve the vertebral column and spinal cord, in general, to be hopeless lesions for which the surgeon's art can do no good. Nevertheless, I am fully persuaded that a considerable share of even the least promising cases are susceptible of permanent relief by judicious treatment from the surgeon; and I am supported in this view by the extremely large proportion of recoveries which has resulted from the attempts to reduce dislocations and fractures of the vertebræ that have been recorded. For instance, thirty-four cases are mentioned in Dr. Ashhurst's tables,[1] in which reduction was attempted by various appropriate procedures, and recovery

Fig. 764.



Posterior view of the vertebral column, ribs, etc., the integuments and muscles having been laid open and deflected from them. (Sibson's Medical Anatomy, Pl. XII.)

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[1] Injuries of the Spine, pp. 71–121. Philadelphia, 1867.

ensued in all but four. In many, the successful issue of the efforts at reduction was indicated by an audible sound or a "snap." In several the paralysis was instantly relieved.

I. INJURIES OF THE SOFT PARTS.

Incised and Punctured Flesh-wounds of the Back.

Wounds are inflicted with cutting and puncturing instruments in the back part of the neck, chest, abdomen, and pelvis, by accidents, by criminal design, and in war, with so much frequency as to require at least some mention of them in this place. For instance, "punctured and incised flesh-wounds of the back were exemplified by fifty-six instances [during our late civil war], of which twenty-one were cases of bayonet-stabs, thirteen of sabre-cuts, and twenty-two of punctures and incisions by sundry weapons. None of these cases are recorded as terminating fatally, though in six the result has not been ascertained; forty-five were sent to duty, and five were discharged. Several of these cases were examples of severe though not dangerous sword-wounds."[1] Of the thirteen examples of sabre-cuts, twelve were received in action. The bayonet-stabs, however, appear to have been inflicted almost entirely by sentries, or by provost-guards, or in brawls, or through accidents. But one example is specified as a wound received in action, and this wound may not have been inflicted by the enemy. Sabre-wounds of the back are seldom mentioned in the literature of surgery. No instance is related by either Guthrie or Hennen. Bilguer, however, gives an instance that occurred in the Seven Years War (1756–63): A cavalry soldier, J. R., while retreating and leaning over his horse's neck, received two cuts in the lumbar region.[2] He appears to have recovered. But Morgagni records an autopsy in a case of sabre-thrust in the back.[3]

Incised wounds which sever to a considerable extent the fasciculi of the trapezius, latissimus dorsi, or rhomboid muscles, are apt to gape widely open. In treating such wounds, it is necessary, after stanching the bleeding and removing the coagula and all other foreign bodies, to introduce at the outset sutures of carbolized silk, which are antiseptic, or of silver or iron wire, which are also antiseptic *per se*, in sufficient number and at sufficiently short intervals, and at a sufficient depth, to bring the divided parts into complete apposition, where they should be allowed to remain until the union is complete. Under this plan of treatment, with quietude, the results of flesh-wounds of the back (incised) are almost always very favorable. But if no sutures be introduced, and the gaping wound be allowed to fill up and heal by granulation, some considerable time may be required before recovery takes place.

Incised or Punctured Flesh-wounds of the Back of the Neck.—If these penetrate deeply, they may open the vertebral or the occipital artery, and thus cause a hemorrhage which, if not restrained, will speedily prove fatal, on the one hand; or, unless promptly treated in a radical manner, will give rise to a traumatic aneurism of an almost equally fatal character, on the other. Hennen, indeed, remarks that "simple incised wounds on the back of the neck, although sometimes penetrating to a great depth, and even uncovering the vertebral arteries, are not beyond the reach of simple bandage, and retention by adhesive strips and sutures; feebleness of the extremities, particularly the lower, is a more frequent source of complaint, in these cases, than hemorrhage."[1] Nevertheless, there are many cases on record in which stabs in the nape of the neck opened one of the vertebral arteries, and thus gave rise to most disastrous consequences. Dr. Kocher, of Berne, relates an excellent example of this sort, in Langenbeck's Archives;[2] and he remarks that it is the twenty-first recorded case of traumatic aneurism of the vertebral artery. In twelve of these twenty-one cases, the wounds were stabs. In ten cases the result was fatal before any pulsating swelling appeared. In eleven cases where life was prolonged until there was pulsating swelling, but two recoveries occurred.[3] Thus it appears that flesh-wounds in the nape of the neck which involve either of the vertebral arteries are exceedingly dangerous to life, that the ratio of mortality for this lesion has, hitherto, exceeded 90 per cent., inasmuch as nineteen out of twenty-one recorded cases have proved fatal, and that the surgical treatment of this form of injury is a subject of very great importance to practitioners as well as to patients. It may be useful to state in this connection the chief causes of this striking want of success. In eleven cases, the carotid artery was tied, through error in diagnosis, and this operation probably rendered the evil greater, by increasing the blood-pressure in the wounded vertebral artery; indeed, in two of the cases thus operated on, the patient died of violent hemorrhage from the seat of injury; and in three other cases belonging to the same category, death occurred from bursting of the aneurism. In five instances, the ligation of the carotid was followed by paralysis that proved fatal. Lücke, in a case where the aneurismal swelling increased rapidly after ligating the carotid, injected into the sac chloride of iron, and also applied plugs saturated with the perchloride; the patient, however, died with symptoms of paralysis. Maisonneuve, in a case of gunshot wound, tied both the vertebral and the inferior thyroid arteries, and extracted the missile. The bleeding was arrested, but death ensued from the infiltration of pus into the spinal canal, and consequent inflammation. One patient died of septicæmia following suppuration of the connective tissue of the neck. In several cases there was hemorrhage that resulted in death.[4] But, as stated above, an error in diagnosis, a mistaking of the wounded artery for a branch of the carotid with consequent ligation of that vessel, was by far the most frequent cause of failure in treating these cases; and, inasmuch as such errors in diagnosis are avoidable when the likelihood of their occurrence is borne in mind by surgeons, there is good reason to hope that much better results will hereafter be achieved in treating flesh-wounds in the nape of the neck which involve either of the vertebral arteries.

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[1] Med. and Surg. History of the War of the Rebellion, Second Surgical Vol. p. 429.

[2] Chirurg. Wahrnehmungen, S. 493. Berlin, 1763.

[3] De Sed. et Causis Morb., Ep. liii. p. 270. 1765.

But flesh-wounds of the posterior cervical region may lay open other arteries of importance as well as the vertebral, for instance, the *profunda cervicis*, a branch of the subclavian, the *arteria princeps cervicis*, a branch of the occipital which inosculates freely with the profunda cervicis, and even the *occipital artery* itself. In Dr. Kocher's case it was, at first, uncertain whether the vertebral or the deep cervical was injured; but the occurrence of hemorrhage on removing the dressing, and the result obtained by introducing a finger into the wound as far as the transverse processes of the vertebræ, whereby the blood was perceived to issue from a point between two transverse processes, apparently the fifth and sixth, soon made the diagnosis clear. In Möbus's case, which is mentioned by Dr. Kocher as the only instance of traumatic aneurism of the vertebral artery, besides his own, which eventuated in recovery, there was a pulsating tumor below the occipital bone on the right side. It might have arisen from a wound of the occipital just as well as from a wound of the vertebral artery; but the pulsation was not arrested by compressing the occipital artery, and the tumefaction was not lessened by compressing the carotid, wherefore the vertebral was inferred to be the seat of the lesion.[1]

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[1] Principles of Military Surgery, p. 285, Am. ed.

[2] Archiv für klin. Chirurg., Bd. xiii. S. 867.

[3] New Sydenham Soc. Bien. Retrospect, 1871–72, pp. 202, 203.

[4] Ibid., p. 204.

Flesh-wounds in the posterior cervical region that also lay open one of the occipital arteries, have proved almost as deadly as similar wounds that lay open the vertebral arteries, mentioned above. The principal reason for these untoward results has been that surgeons, owing to difficulties real or fancied that they have met with in trying to tie the wounded occipital artery in the wound itself, have resorted to untrustworthy expedients, instead of persevering as they should have done until success had crowned their efforts to ligature the bleeding vessel on each side of the aperture in its walls. From the employment of temporizing measures, it has resulted that the hemorrhage, although restrained for a brief period, has burst forth afresh from day to day or from time to time, until, finally, the patient has perished miserably from anæmic exhaustion, or, in other words, has slowly bled to death, and that, too, beneath the surgeon's very eyes. The following example well illustrates this subject.

A young man, aged 22,[2] received in an affray a stab-wound in the neck, two inches in length by one inch in depth, behind the left ear, and about two inches distant from the auditory meatus. Half an hour afterward the medical man found him pale and faint from loss of blood. The hemorrhage still continued in feeble jets; but pressure applied at the bottom of the wound with a finger readily suppressed it. On failing to grasp the wounded artery with forceps, it was resolved to treat the hemorrhage by compression. Thereupon the wound itself was stuffed with lint, and the lips thereof were drawn together over it, and secured in apposition with interrupted sutures. This proceeding controlled the hemorrhage for five days, when slight bleeding recurred. On the sixth day there was more hemorrhage. On removing the dressing the bleeding was very profuse, and could not be entirely suppressed by pressure with a finger in the wound. The left common carotid artery was then tied, and the bleeding ceased. Three days afterward, however, a slight hemorrhage appeared in the original wound, and in twelve days more hemorrhage again occurred from the same wound, on opening which, the blood was found to issue from the occipital artery, at a point behind the mastoid process. Manual compression was now resorted to, but two days subsequently the patient died, having survived the wound twenty-three days, and the deligation of the common carotid artery seventeen days. An *autopsy*, made ten hours after death, showed that the knife had penetrated between the mastoid process of the left temporal bone and the transverse process of the atlas, and had opened the occipital artery in the occipital groove. The occlusion of the carotid was perfect. The brain was not diseased. Death appears to have resulted from anæmic convulsions and anæmic exhaustion, that were caused by the regurgitant hemorrhages from the wounded artery.

Deligation of the common carotid in this case failed to control the hemorrhage, because it did not control the circulation of blood in the wounded part of the occipital artery; and it did not control the circulation because of the great freedom with which the terminal branches of the two occipital arteries inosculate with each other across the median line, and with branches of the temporal and posterior auricular arteries in the scalp, and likewise by means of the arteria princeps cervicis with the profunda cervicis in the deep part of the neck. In consequence of the great freedom of this arterial intercommunication, the closure of the common carotid was not attended with such a stoppage of the blood-flow in the wounded part of the occipital artery as is requisite for the formation of blood-clots which can permanently close the aperture in the arterial tunics, and thus effectually restrain the hemorrhage. Wherefore it happened, that, as soon as the blood-pressure rose again after the operation of tying the common carotid was performed, the occluding clots were driven out of the aperture in the arterial tunics, and the bleeding started afresh from the distal as well as from the proximal portion of the wounded artery. Thus it is shown that the only procedure which might have saved this patient would have consisted in tying the injured artery in the wound itself with two ligatures, one of them being applied on each side of the aperture in its walls, so as to prevent the regurgitant as well as the direct hemorrhage; and had this operation been promptly performed by the physician who first saw the patient, there is good reason to believe that he would have promptly recovered.

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[1] Ibid., p. 204.

[2] American Medical Times, May 18, 1861, p. 320.

In *treating* flesh-wounds of the posterior cervical region which open any bloodvessel of importance, the first and the most important indication consists in suppressing the hemorrhage, without delay, by applying two ligatures to the injured vessel in the wound itself, placing one of them on each side of the bleeding aperture in its walls. To fulfil this indication it will be necessary to bring the bleeding orifice or ends of the vessel distinctly into view; and, to this end, whenever the wound is not large enough to allow the bleeding point or points to be seen and secured with ligatures, the surgeon, having first introduced a finger of his left hand into the wound, and placed the tip of it on the spot whence the blood issues from the vessel, so as to control the hemorrhage for the time being, should enlarge the wound with a bistoury, held in his right hand, until the source of bleeding is fairly brought into view, bearing in mind, of course, the anatomical structure of the parts involved, and carefully avoiding all nerves and other organs of importance. Then he must ligature the distal as well as the proximal end of the wounded artery, in order to repress the regurgitant as well as the direct hemorrhage; and, in cases where the artery is not already completely divided, it is well to finish the operation by completing the division of the arterial tube with a bistoury, applied midway between the two ligatures, so that the ends of the vessel may be allowed to retract and contract. However great the obstacles in such cases may be, the surgeon must persevere until he has overcome them, and has suppressed the hemorrhage in this radical manner; otherwise he will pretty certainly be annoyed and mortified by seeing his patient slowly bleed to death, in spite of all that he has done, as happened in the case just related.

The application of a distal as well as a proximal ligature to the vertebral artery, when wounded, is quite as necessary as it is in the case of the occipital, or the profunda cervicis; for the two vertebrals unite together to form the basilar artery, and, therefore, the blood is capable of regurgitating in either of them with great force. But a large part of the course of each vertebral artery is occupied by its passage through the foramina in the transverse processes of the upper six cervical vertebræ, together with the spaces intervening between the transverse processes of these six cervical vertebræ. Now, the vertebral artery is not unfrequently wounded in this part of its course, and here, because of its anatomical relations, ligatures cannot be applied. What, then, is to be done in such cases in order to stanch the hemorrhage? Happily this problem has been solved by Dr. Kocher, who has presented us with a successful example, already several times referred to above. His plan of treatment I shall now proceed to describe:—

The patient was a man, aged 48. He had a stab-wound in the nape of his neck, the hemorrhage from which had been restrained to a considerable extent by plugs soaked in styptic solutions, etc. On removing the dressings, there was seen at the level of the fifth and sixth cervical vertebræ, about an inch to the left of the spine, a roundish wound about two-thirds of an inch in diameter. On removing the coagulum which lay in the wound, some dark blood escaped; and, on withdrawing the finger used for exploration, a rather violent hemorrhage of bright red blood followed. The wound was then laid open to the extent of about three inches, and a large quantity of coagulum was removed by the finger. Thus a cavity was found, having the size of a small apple, and at the bottom the posterior surfaces of the left articulating processes were felt, and, more distinctly, the transverse processes of the vertebræ. A transverse incision was now made, an inch and a half in the anterior, and half an inch in the posterior direction; and the blood was then seen to issue from a point between the transverse processes of two vertebræ, apparently the fifth and sixth cervical. The blood escaped from the distal as well as from the proximal portion of the artery; and the hemorrhage was arrested by pressing against the transverse processes, either from above or from below. No ligatures could be applied to the wounded artery. A plug of charpie of the size of a pea, soaked in a solution of the perchloride of iron, was therefore introduced between the transverse processes, and left there. It stopped the bleeding. The external wound was closed with sutures, and dressed antiseptically. The head was kept fixed by a stiff collar. On the fourth day after the operation, the plug in the deep part of the wound was removed, partly by means of a stream of water, partly by forceps; no bleeding followed. The patient was discharged cured, a little more than five weeks after the operation.[1]

In similar cases, the wounded vertebral artery might be successfully plugged by pressing into its lumen one or more cones, made out of fresh animal tendons (readily procurable at almost any butcher's stall), having the diameter of a pea, and having been smeared over with a strong solution of ferric perchloride, instead of a wad of charpie. The animal-tissue plugs could be allowed to remain *in situ*, where ultimately they would undergo absorption and be replaced by new connective tissue. Both ends of the wounded vertebral artery must, in general, be plugged.

When the muscular and connective tissues of the neck are extensively infiltrated with blood, as soon as the wounded artery has been securely ligatured or plugged, and the coagula have been removed, the wound itself should be thoroughly cleansed with a two-per-cent. solution of carbolic acid. Externally, the wound having been closed by interrupted sutures should be dressed antiseptically, and should have left in it an adequate drainage tube, reaching to the bottom. Thus, septicæmia, which is very apt to appear and prove fatal in such cases, may be avoided.

Hennen calls attention to the fact that in wounds of the back, "sinuses are also very apt to form along the spine, and they often prove very troublesome; I would never trust [he justly observes] to pressure in these cases, but would make a free though cautious incision. These incisions are sometimes rendered very necessary by the lodgment of balls, pieces of cloth, etc."[2]

These sinuses and abscesses along the spine and in the muscles of the back having been freely opened, their contents discharged, and all foreign bodies removed, they should be thoroughly washed out by injecting a two-per-cent. solution of carbolic acid, and should be treated by securing complete drainage with velvet-eyed tubes of rubber, deeply inserted, as well as by applying antiseptic dressings externally.

To sum up the treatment of flesh-wounds which also lay open important arteries in the posterior cervical region:—

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[1] New Sydenham Soc. Bien. Retrospect, 1871–2, pp. 202, 203.

[2] Op. cit., p. 350.

(1) The diagnosis as to what vessel is injured must be made by exploring the wound itself with a finger, ascertaining by the tactile sense the point whence the blood issues, and determining by the same means its anatomical relations.

(2) The bleeding vessel must be brought into view by enlarging the wound without delay; and it must then be tied at the place of injury with two ligatures, one of them being applied on each side of the aperture in its walls, or to each end of the artery if it be severed. The artery should be divided midway between the two ligatures, for the purpose of allowing its ends to retract and contract, in all cases where it has not been severed by the original wound.

(3) When one of the vertebral arteries is wounded in that part of its course which lies in the canal formed by the foramina in the transverse processes of the six upper cervical vertebræ, the hemorrhage must be restrained by plugging the injured artery in the manner described above, because in this situation ligatures cannot be applied.

(4) These wounds should be thoroughly cleansed with antiseptic lotions. Their lips should then be drawn together, and held in apposition, by means of interrupted sutures. Should the occurrence of deep-seated suppuration be probable, adequate drainage tubes should be inserted. Antiseptic dressings should be employed externally.

(5) Inasmuch as there is great flexibility in the neck, fixing the head by means of a stiff collar, so as to secure quietude in the cervical muscles, will considerably expedite the recovery, and diminish the liability to secondary hemorrhage; and it should therefore always be employed in these cases.

I have considered the flesh-wounds in the posterior cervical region which involve also the vertebral, the occipital, the deep cervical, or other arteries, at considerable length, because of the enormously high rate of mortality which has attended the reported examples of these lesions, amounting to fully 90 per cent.; and I believe that the principles of treatment enunciated above, when generally applied in practice, will greatly lessen this awful ratio, and correspondingly increase the chances of recovery from these exceedingly troublesome forms of injury.

INCISED OR PUNCTURED FLESH-WOUNDS OF THE BACK, RECEIVED BETWEEN THE SHOULDER-BLADES.—These wounds not unfrequently penetrate the thoracic cavity. The following example, taken from my note-book, affords a good illustration of this point:—

A government teamster, middle-aged and robust, was stabbed in the back, at Washington, August 15, 1861, in a brawl. He received a cut about three inches in length, extending up and down, between the base of the left scapula and the spinous processes of the dorsal vertebræ, but rather nearer to the scapula than to the spinous processes. The muscles were divided down to the ribs, and the left pleural cavity was freely opened, so that air in large quantity was drawn into and expelled from that cavity by each respiratory movement. He was at once taken to the E Street Infirmary. When admitted, he was much prostrated from shock, and had considerable dyspnœa. As soon as the bleeding was completely stopped, which required a little time, the lips of the wound were brought into apposition and retained by three points of interrupted suture, and by strips of adhesive plaster.

August 20.—Most of the wound has united by the "first intention," and he has convalesced thus far without even one unfavorable symptom. There has been no pain in the side nor any other sign of pleurisy. Subsequently he did well in every respect, and soon left the hospital entirely cured.

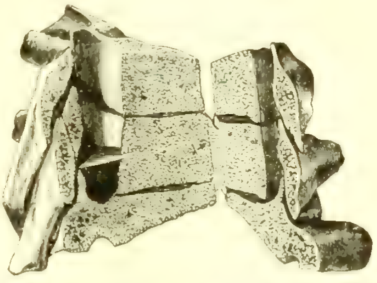
It was observed in this case that the wound gaped considerably; and, therefore, each of the three points of interrupted suture was passed through the rhomboid muscle, as well as through the exterior plane of muscles and the skin. Thus the edges of the wound were securely held in close apposition, and a speedy recovery was obtained.

Incised wounds of the back not unfrequently perforate the theca vertebralis, and lay open the spinal canal. The occurrence of this lesion is attended with the escape of cerebro-spinal fluid; and, in cases where the spinal cord and spinal nerves had not been injured, the escape of this fluid through the wound would alone indicate the nature of the lesion.

Professor Agnew has pointed out "the exposed condition of the contents of the spinal canal in the posterior region of the neck," and states that "it is due to the horizontal direction of the spinous processes, by which vulnerable spaces are left between." Professor Agnew also says: "The popular notion that posterior cervical wounds are followed by sexual impotence must be founded on cases of injury to the cord or its membranes. The testimony of Legouest, who had abundant opportunities for observation on this point during the conflicts of the French with the Turks, gives no countenance to this opinion."[1]

But incised wounds in the posterior region of the chest also not unfrequently penetrate the spinal canal, and cause paraplegia by injuring the spinal cord, notwithstanding that the spinous processes of the dorsal vertebræ do not extend in a horizontal direction. The following example occurred during the late civil war:—

Fig. 765.



The fourth, fifth, and a part of the sixth dorsal vertebræ, sawn open to exhibit the blade of a knife which had broken off after traversing the spinal canal and spinal cord. (Spec. 1160, A. M. M.)

Private George S., Co. B, 15th New York Engineers, was admitted to Armory Square Hospital, Washington, April 22, 1863, having been stabbed with a knife in the back at Falmouth, Va., on the 20th, that is, two days before. He was completely paraplegic; the urine had to be drawn off by a catheter; and nothing but croton oil, in three drop doses, succeeded in moving his bowels, three days after admission; two days after that, involuntary defecation and micturition set in. Sphacelus of all the projecting points on the lower part of his body soon followed, and proceeded rapidly until it nearly exposed the spines of the sacrum. On May 10, chills came on, and recurred daily. Death ensued on May 26, from exhaustion. The *autopsy* showed that the knife had penetrated the fifth dorsal vertebra. The fourth, fifth, and a part of the sixth dorsal vertebræ were removed and sawn through longitudinally to exhibit the knife-blade, which appears to have been broken off, and to have remained fixed in the body of the fifth dorsal vertebra ever since the injury was inflicted. The specimen is preserved in the Army Medical Museum; and it is represented by the accompanying wood-cut. (Fig. 765.)[2]

Another instance of incised wound of the back, involving the vertebral column, was likewise recorded during the late civil war:—

Private Wm. D. Cook, company D, 6th Tennessee Cavalry, aged 25, was admitted to Overton Hospital, Memphis, Tenn., November 25, 1864, with an incised wound of the spine inflicted on the 10th, that is, fifteen days before, with a knife. Simple dressings were applied. The patient was returned to duty on December 15.[3]

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[1] Principles and Practice of Surgery, vol. i. p. 321.

[2] Medical and Surgical History of the War of the Rebellion, First Surgical Volume, p. 425.

[3] Ibid., p. 45.

In this case it does not appear that the spinal cord or spinal nerves sustained any injury. No other examples belonging to this category were reported during the late civil war.

Dr. Meryon[1] presents a very instructive case of incised wound in the back, penetrating the vertebral column and injuring the spinal cord, in which complete recovery took place.

A boy, aged 15, received a wound from a cutting instrument in the back, which penetrated between the tenth and eleventh dorsal vertebræ, and probably divided the right half of the spinal marrow. There was complete paralysis of motion, and incomplete loss of sensibility in the right thigh and leg. The patient made a good recovery, and at the end of two months was able to walk four or five miles. A prominent symptom in this case, which has often been observed in similar cases, was the escape of a quantity of cerebro-spinal fluid from the wound during the first twelve days after the injury.

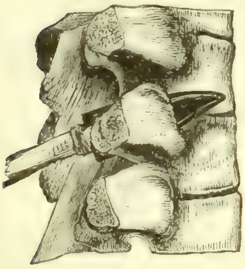
Dr. Schwandner reports a somewhat similar instance, in which a punctured wound of the back injured the spinal cord between the second and third dorsal vertebræ. Paralysis of the right foot and leg, shortness of breathing, together with involuntary defecation and micturition, were present. The foot remained partially paralyzed; but, in other respects, the recovery was complete.[2]

Under the head of punctured wounds of the back, the following examples are also embraced:—

Hennen reports that, "in a sergeant of the Enniskillen Dragoons, wounded at Waterloo, a piece of the shaft of a Polish lance stuck fast between the spinous processes of the last two dorsal vertebræ, completely paralyzing him until it was removed."[3]

In arrow-wounds of the back the missile sometimes penetrates the vertebral column, as happened in a case the specimen from which is represented by the accompanying wood-cut (Fig. 766). This specimen was obtained from the body of a white man killed by Indians (by an arrow-wound of the heart, etc.) in 1869, at an outpost near Fort Concho, Texas, and was sent to the Army Medical Museum. It consists of the fourth and fifth, together with portions of the third and sixth, dorsal vertebræ. An arrow-head is shown impacted in the right transverse process of the fourth dorsal vertebra and posterior extremity of the rib. The spinal canal was not opened by the missile.[4] "The force with which arrows are projected by the Indians is so great that it has been estimated that the initial velocity of the missile nearly equals that of a musket ball. At a short distance an arrow will perforate the larger bones without comminuting them, or causing a slight fissure only."[5]

Fig. 766.



Showing an arrow-head, impacted in the right transverse process of the fourth dorsal vertebra.—(Spec. 5673, Sect. I. A. M. M.)

One example of an incised flesh-wound of the *sacral region* has come under my own observation. The patient was a lad, aged about 18, who was cut by the lower angle of an axe that accidentally fell from his right shoulder, upon which he was carrying it as he walked, and struck against the sacrum, a little to the right of the median line. The wound was about two and a half inches in length, extending somewhat obliquely from above downward, and penetrated to the bone, which was also slightly cut by the edge of the axe. There was considerable hemorrhage, but no ligatures were required. The bleeding having been stanched, and the coagulum entirely removed, the edges of the wound were brought into apposition, and fixed without difficulty by strips of adhesive plaster. The wound united throughout by the first intention, but the patient complained for a long time of having pain and soreness in the sacrum beneath the cicatrix. These symptoms, however, ultimately disappeared without the occurrence of suppuration or the discharge of any pieces of bone.

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[1] Researches on the Various Forms of Paralysis, p. 69. London, 1864. Quoted from L'Union Médicale, 1860, p. 552.

[2] New Sydenham Soc. Year-Book, 1859, p. 429.

[3] Op. cit. p. 350.

[4] Circular No. 3, S. G. O., August 17, 1871, p. 153.

[5] Ibid., p. 160.

CONTUSIONS AND CONTUSED WOUNDS OF THE BACK.

The skin on the dorsal region of the human subject is so thick and strong that it will stand a great deal of hard usage without breaking. There is, however, a considerable liability to the occurrence of contusions and contused wounds in the posterior cervical, dorsal, lumbar, and sacral regions, from railway accidents, from falls, from blows with blunt instruments, and from the impact of falling bodies or of the missiles of war. The following examples are in point:—

Contusion of the Sacral Region from a Railway Accident.—Private John Holden, Co. C, 29th Infantry, aged 23; was injured at Keswick, Va., September 28, 1868. He was admitted to the post hospital at Camp Schofield, Lynchburg, on the next day, and stated that, while riding on the top of a box car, and seeing the next car in front rolling over an embankment, he jumped off, but, being unable to escape, was struck on the back by the car as it rolled over. He complained of intense pain over the sacrum, extending between the anterior superior spinous process and the right tuber ischii. The parts over the sacrum were exceedingly tender under pressure, the slightest motion or touch causing him to scream with pain. No crepitus could be elicited. He could flex the leg on the thigh without pain, but was unable to flex the thigh on the pelvis. The injured part was much ecchymosed; and he had a dull, moving, continuous pain, extending across the whole front of the pelvis. Anodynes, with a nourishing diet, were administered. The patient made a good recovery, and was returned to duty on November 26.[1]

Contusions of the Dorso-Lumbar Region from Blows with the Butt-end of a Musket.—Private Thomas Carroll, Battery L, 1st Artillery, aged 23, presented himself at surgeon's call October 5, 1867, at Fort Porter, N. Y., stating that, some time during the previous night, he had been struck in the back with the butt-end of a musket in the hands of a sentinel. The blow had knocked him down, whereupon he had been struck twice in the splenic region with the same weapon. On examination, a slight wound, such as might have been made by the percussion hammer of a musket, was found about an inch and a half to the left of the articulation of the twelfth rib with the twelfth dorsal vertebra. About two inches lower, at the same distance from the second lumbar vertebra, another wound of the same character was found. The man was treated in the post hospital at Fort Porter, until Oct. 21, when he was returned to duty entirely cured.[2]

Contusion of the Back caused by a Fall.—August Burtz, artificer of Co. H, 2d Infantry, aged 38, was admitted to the hospital at Taylor Barracks, Ky., November 7, 1868, having fallen from a ladder to the floor, a distance of fourteen feet. He complained of pain in the bowels, and inability to pass water, and suffered considerably from shock. A stimulant and an anodyne were administered. On the 8th he was improved. On the 10th he was taken with intermittent fever, which yielded to quinine and iron. He speedily recovered, and was returned to duty on the 15th.[3]

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[1] Circular No. 3, S. G. O., August 17, 1871, p. 106.

[2] Ibid., p. 106.

[3] Ibid., p. 106.

These examples well illustrate the usual course of ordinary contusions of the back, when they are treated with quietude, nourishing food, and anodynes, as required. But, these excellent results are not always so easily, nor so speedily obtained, by even the best-devised plans of treatment; as the following case, in which a severe bruise of the sacral region was followed by periostitis and sub-periosteal abscess, will serve to show:—

Private Thomas Morgan, Co. A, 42d Infantry, aged 34, was admitted to the hospital at Fort Niagara, N. Y., October 2, 1867, the wheel of a loaded cart having passed over his pelvis on the previous day. There was swelling, together with extensive ecchymosis, of the integuments over the upper part of the sacrum, and he complained much of pain. He also was not able to walk. A stimulating lotion was applied to the contused part, and anodynes were administered. A tumor, which formed in the injured part, was several times evacuated by incisions. The patient likewise suffered from chills and fever. By November, his general health had improved under expectant treatment; but the wound of operation was still open. On December 6, he was permitted to do light duty. On the 27th he was returned to hospital; the wound was swollen, inflamed, and freely discharged dark purulent matter. The swelling having subsided by January 13, 1868, and the condition of the wound remaining unchanged, an incision three inches long was made down to the diseased structure, which was found to be a hard cartilaginous growth containing osseous deposits, between which and the periosteum the purulent matter had been lodged, and had been escaping therefrom by means of an opening. On dissecting out this morbid growth, and touching the walls of the residual cavity with nitrate of silver, the wound was closed with adhesive strips, and a compress was applied. But little suppuration followed; and, on the 28th, the wound being nearly healed, the patient was returned to duty.[1]

Not unfrequently, however, the degree of injury is much more considerable than it was in either of the above-mentioned cases, and the process of reparation then consumes much time, on the one hand, or a fatal result ensues from sloughing of the injured part, from long protracted suppuration, or from septicæmia, on the other. One of these conditions is very apt to obtain in cases where the injury is inflicted by the missiles of war. A striking example of violent contusion of the soft parts in the dorso-lumbar region came under my observation at Stanton Military Hospital, during the late civil war.

The patient, who was a soldier, tall, broad-shouldered, and very strongly built, aged about 30, was injured by the explosion of a shell while lying on the ground face downwards, probably in line of battle. He thought that the butt-end of a shell had struck his back. On examination, there was found centrally situated in the dorso-lumbar region, a circular portion of the skin fully six inches in diameter, that was very much discolored by ecchymosis, although wholly unbroken, was raised up considerably above the surrounding surface, and exhibited fluctuation distinctly when the fingers were applied to it, because a copious extravasation of blood into the subcutaneous connective tissue had taken place. So there was in reality present an immense hæmatoma, having a flattened shape, and a diameter of at least six inches, the product of an exceedingly powerful blow on the middle of the back, which did not break the skin. The treatment consisted of quietude, a nourishing diet, the administration of anodynes, and the application of camphorated oil to the injured part. But, notwithstanding the care taken to prevent it, the integuments sloughed off throughout the whole of the circular space above mentioned, and the extravasated blood was completely discharged thereby, leaving, however, a healthy granulating surface fully six inches in diameter. Simple dressings with unguentum resinæ were applied, the supporting plan of internal treatment was continued, and the sore rapidly cicatrized. When his recovery was far advanced, the patient was transferred to a northern hospital, and thus passed out of my sight.

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[1] Ibid., p. 108.

Concerning the occurrence of contusions of the back in the Crimean War, Staff-surgeon T. P. Matthews writes: "Very many wounds of this region were inflicted by shell, and the position uniformly adopted as safest while awaiting a shell explosion, viz., lying on the face, accounts for this. The contusions were often large and serious, and, when not immediately fatal, enormous masses of tissue often sloughed out, and the patient died exhausted and worn out by profuse suppuration, or, if recovery took place, the wound healed by the granulating process."[1]

Hennen reports the following case of contusion of the back from a spent cannon-ball, which proved fatal:—

> A gallant artillery officer received a contusion from a spent round-shot, at the battle of Vittoria, which struck him exactly between the scapulæ, barely leaving a discoloration of the skin, and a slight stiffness of the parts. To this he was advised to apply cloths wet in a saturnine solution, which he gradually increased in strength. He derived, however, very little benefit from this mode of treatment; the stiffness still continued, the discoloration increased, and he was advised by some casual visitor to apply a blister to the part. In an evil hour this advice was acceded to; and in a very few days the whole back, down to the lumbar region, was covered with a dusky erysipelatous inflammation. Sloughing abscesses speedily formed in the injured part, which were attended with a horribly offensive discharge; and, in a few weeks, death closed the scene.[2]

Hennen also justly remarks concerning this case: "To apply strong saturnine solutions, or leeches, to a part under these circumstances, is extremely injurious, because they tend to depress still more the powers of life; to over-stimulate by blisters is equally destructive of the vitality of the parts, and more hurtful to the general constitution."[3]

As to the *treatment* of contusions of the back when caused by the explosion of shells or the impact of spent cannon-balls, there are three points to be most carefully attended to in managing these cases: *First*, the lotions applied as discutients should not be purely sedative, nor powerfully exciting, but of a mildly stimulating nature. *Secondly*, when effusions of blood (hæmatomata), or formations of purulent matter (abscesses), are clearly diagnosed, and require removal, they should be evacuated through small valvular apertures, and the admission of air should be avoided, as far as possible. *Thirdly*, the dressings should be antiseptic in their nature; for instance, a two-per-cent. solution of carbolic acid in water already containing ten per cent. of alcohol, or a four-per-cent. solution of carbolic acid in camphorated oil, should constitute an important element of the dressings. Furthermore, a nourishing diet should generally be allowed in these cases, and, not unfrequently, alcoholic stimulants also.

LACERATED FLESH-WOUNDS OF THE BACK.

Hippocrates, in the twenty-third section of his work on wounds, treats briefly of wounds of the back, and directs attention almost exclusively to those inflicted by the lash, that is, to certain forms of lacerated wound occurring in this region. For the cure of these injuries he recommends the application, at first, of cataplasms, consisting of boiled onions or of squills; and, subsequently, of an ointment made of goat's fat or fresh lard, together with oil, resin, and salt of copper—a preparation upon the whole not unlike the ceratum resinæ of the modern pharmacopœia (a most useful dressing for slowly healing and indolent sores), to which a small percentage of cupric sulphate or acetate has also been added.

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[1] Med. and Surg. History of the British Army in the Crimea, vol. ii. p. 336.

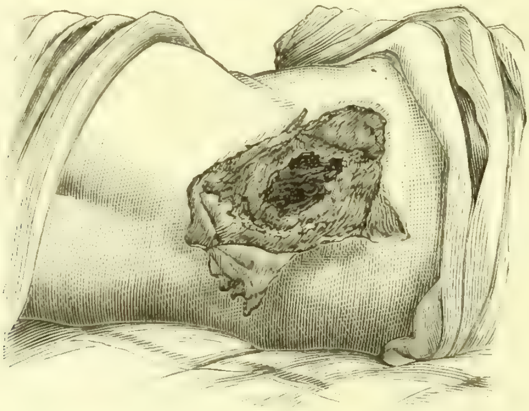
[2] Op. cit., pp. 92, 93.

[3] Ibid., p. 93.

But some of the most impressive instances of lacerated flesh-wounds of the back, on record, have resulted from explosions of shells. The next two examples are reported in the Medical and Surgical History of the War of the Rebellion, and they will serve to illustrate this topic in an excellent manner:—

A soldier, aged 19, was wounded July 13, 1864, in the entrenched lines before Petersburg, by a large shell-fragment, which tore away the dorsal integuments over a space measuring at least six by eight inches, and severely lacerated the subjacent muscles, but without injuring the ribs or the vertebral column. There was no bleeding, and the shock was comparatively slight. The lesion is well shown by the accompanying wood-cut (Fig. 767). The patient, after partaking of restoratives, and having the raw surface of his wound covered up by a water dressing, was taken to the Depot Field Hospital, at City Point. While here, only such tissues sloughed as were utterly disorganized by the projectile, and the large surface that was exposed soon granulated kindly, so that, after a month, the patient was in a condition to be transferred northward; and, on August 15, he entered the Whitehall Hospital, at Bristol, Pa. The cicatrization progressed rapidly. On September 12, he was furloughed, and on October 4, he was readmitted, being fairly convalescent. On January 23, 1865, he was sent for modified duty in the Veteran Reserve Corps. On June 24, he was mustered out of the service. No application for a pension has been made by this man or his heirs.[1]

Fig. 767.



Showing a shell-wound of the back, 6 by 8 inches in extent. Recovery ensued.

Inasmuch as the men were often ordered to lie on the ground, face downward, while under artillery-fire, huge lacerations of the back were not infrequently observed by our military surgeons during the late civil war. Commonly, however, these wounds rapidly healed, as happened in the case just related. But, sometimes, the process of reparation was very slow after such lacerations. Other conditions being equal, flesh-wounds in the flanks and buttocks were found to be more serious than those in the upper dorsal region. In cases where large masses of muscular tissue were torn away, the cicatrization was sometimes protracted for years, as happened in the following instance:—

A soldier, aged 20, was wounded at the battle of Chancellorsville, May 3, 1863, by the explosion of a shell. The integuments over the gluteal and lumbar regions were torn off, and, on the right side, a large portion of the gluteal muscles was also removed. This huge wound is well illustrated by the accompanying wood-cut (Fig. 768). The shock appears to have been considerable. On May 8, reaction having taken place, the patient was sent to Armory Square Hospital, at Washington. He suffered but little pain, and had a good appetite. He was ordered the best of diet, with porter; lint wet with a disinfectant lotion to the wound; and an anodyne internally at night. The patient did well until the forenoon of the 15th, when he complained of inability to separate his jaws, and of stiffness in the muscles of the neck. The trismus was attended next day by opisthotonos and other tetanic symptoms, caused perhaps by spinal meningitis. Large doses of morphia were administered at short intervals, and with a good effect. On the 22d, a large dejection from the bowels occurred. From this date the patient steadily improved. On July 10, he was furloughed. On November 24, he returned to the hospital. On December 5, an examination showed that the wound had cicatrized, excepting a patch having the size of the palm of a hand, and that this portion was kindly granulating. The right buttock was wasted and flattened. His gait was feeble and uncertain. His general health appeared to be good. On December 15, he was discharged from the service and pensioned. A drawing in colors of the huge wound in this case, as well as of that in the preceding case, was made by Hospital Steward Stauch soon after the reception of the injury. Both drawings are preserved in the Army Medical Museum. An excellent chromo-lithograph, made from the drawing in the last case, is presented in the second volume of the Surgical History of the War. The accompanying wood-cut (Fig. 768) is a copy (reduced) of the chromo-lithograph. On November 30, 1870, the pension-examiner reported as follows in the case: "A shell-wound over sacrum of large extent; is not so well as formerly; the sore now shows no disposition to heal, and, in all probability, will remain an open ulcer. His weight is 130 pounds; the pulse 70; the respiration normal; disability total." In 1871, the late Dr. Otis, the much-esteemed editor of the Medical and Surgical History of the War, addressed a note of inquiry to this soldier, regarding

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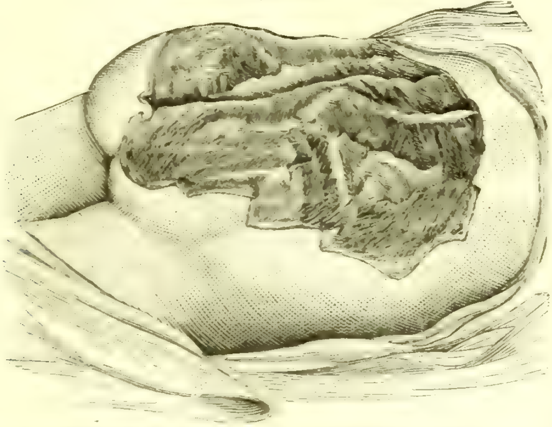
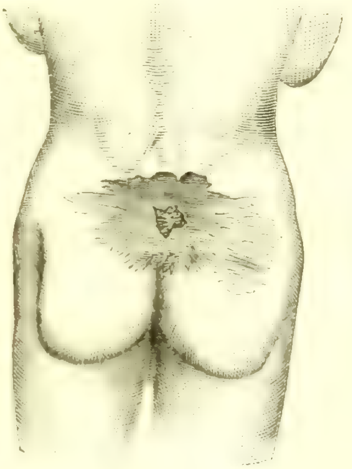
[1] Medical and Surgical History, etc., Second Surgical Volume, p. 429.

Fig. 768.



Showing an immense shell-wound of the lumbar and gluteal regions: tetanus: recovery.

Fig. 769.



Showing the appearance of the cicatrix nine years after the wound represented in Fig. 768 was inflicted. In the centre of the cicatrix an indolent ulcer of irregular shape remains.

the condition of his wound. His attorney courteously responded to this letter, and transmitted a photograph and diagram of the cicatrix, which then bounded a raw surface of irregular shape, three inches wide by two inches in height. The photograph is reproduced in the accompanying wood-cut (Fig. 769). For a long time the granulations on this raw surface had been indolent, and the cicatrization had made no progress; there were no sinuses nor fistulous tracks to indicate the existence of diseased bone, or of any other internal cause of irritation. The invalid's general health was satisfactory. Dr. Otis advised that M. Reverdin's plan of skin-grafting, on which Messrs. Bryant and Pollock had latterly reported so favorably, should be resorted to; but, at the time of writing, he had not been informed whether this advice had been followed.[1]

G. Fischer[2] cites the case of a French soldier, who, while kneeling, was struck by a rolling cannon ball, which carried away a portion of the buttocks having the size of a dinner-plate. In another instance, a piece as large as a man's hand was torn off. In both cases luxuriant granulations arose, and complete recoveries were expected.

Concerning the *treatment* of this class of injuries, not much remains to be said. The chief risks pertaining to them arise from a liability to the occurrence of tetanus, of spinal meningitis, of septicæmia, of pyæmia, or of exhaustion from profuseness and protractedness of the suppuration. The plans of treatment should, therefore, be framed with a view to avoid the occurrence of these complications as far as possible. To this end, the dressings applied to the wounds should always be antiseptic in their nature, a nourishing diet, with tonics and stimulants, should generally be allowed, and constitutional irritation, as well as pain, should be promptly allayed by a judicious administration of opium or morphia. The action of opiates in these cases, to allay nervous irritation, may sometimes be advantageously supplemented by exhibiting the bromides or chloral hydrate. The cicatrization of the wounds, especially when the sores are large, and have become chronic, should be aided by introducing skin-grafts, as recommended for this class of injuries by Dr. Otis.

In civil life, immense lacerated wounds of the back are sometimes inflicted with the implements of labor, accidentally or designedly. For example:—

> "Dominick Jeffri, an Italian laborer, was struck in the back with a pickaxe in the hands of John Cannon, a fellow workman, and fatally injured yesterday. The men, who were recently arrived emigrants, were employed in making an excavation for gas pipes on Atlantic Street, Brooklyn, when Jeffri stepped backward in a stooping position just as Cannon's pick was descending. The full force of the blow drove the sharp-pointed, heavy pick through the back, near the spine, for the depth of five or six inches, causing the blood to flow from a terribly lacerated wound.[3]

The treatment of this form of injury should be conducted on the principles which have already been laid down.

Gunshot (small-arm) Flesh-wounds of the Back.

In the Second Surgical Volume of the Medical and Surgical History of the late Civil War, at page 428, there is presented a tabular statement embracing 12,681 cases of gunshot flesh-wound of the back. The number of deaths was exactly 800, which gives a ratio of mortality of a trifle over 6 per cent. The proximate causes of death are specified in 380 of these cases. Eighty-three of them were complicated by other wounds. Of the remaining 297 patients, 27 are reported as having succumbed to *tetanus*,[1] 33 to *secondary hemorrhage*, and 28 to *gangrene*. The fatal termination was ascribed to *surgical* or *traumatic fever* in 17 cases, to *pyæmia* or *septicæmia* in 67 cases, to *pneumonia* or *hepatitis* (probably instances of embolism) in 17 cases, to *erysipelas* in 8 cases, to *typhoid fever* in 31 cases, to *diarrhœa* and *dysentery* in 39 cases, and to *peritonitis* in 7 cases. In one instance the administration of *chloroform*, it was thought, caused the fatal result. Two patients died from *diphtheria*, two from *smallpox*, and 18 from various intercurrent disorders due to "*hospitalism*," and not directly connected with the traumatic lesions. Dr. Otis makes the following observations, which may be of special interest to statisticians: "Analysis of this large series of gunshot flesh-wounds indicates that the mortality of these non-penetrating wounds has been over-estimated by some European writers of acknowledged authority in matters pertaining to surgical statistics. Making every allowance for errors, and admitting that the aggregate may have been swelled by the admission to hospital of trivial cases of wounds of the integuments, the percentage of mortality remains much lower for this group of injuries than has been heretofore represented."[2]

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[1] Ibid., p. 430.

[2] Deutsche Zeitschrift für Chir., 1872, Bd. I. S. 198. (Otis.)

[3] N. Y. Herald, June 8, 1882.

The foregoing exhibit of the causes of death which were noted in 12,681 cases of shot flesh-wounds of the back, shows that these lesions were but seldom mortal, unless septicæmia, pyæmia, gangrene, or tetanus (that is, traumatic spinal meningitis) supervened, or arterial hemorrhages occurred, which, doubtless, were not infrequently maltreated, and so proved fatal, as I have shown, on a previous page, was the case in numerous instances of incised and punctured wounds of the posterior cervical region. Nevertheless, septicæmia, pyæmia, gangrene, tetanus, and maltreated arterial bleedings, were encountered with such frequency in this class of injuries as to make the employment of special precautions against their occurrence a necessary feature in every plan of treatment. The destructive effects of "hospitalism," and of exposure to infectious disorders, such as typhoid fever, smallpox, and diphtheria, were likewise observed with such frequency as to require the adoption of preventive measures.

But flesh-wounds of the back, inflicted by small-arm missiles, usually—that is, in a large majority of instances—gave no particular trouble, and soon terminated in recovery. The following example will serve to illustrate this point:—

Private John Cosgrove, Company F, Eighth U. S. Infantry, aged 23, was wounded March 17, 1869, by a conoidal ball, which entered the right side of his back near the fifth lumbar vertebra, passed forward and outward, and emerged immediately over the anterior superior spinous process of the ilium. He was admitted to the post hospital at Columbia, S. C., on the 18th. Simple dressings were applied, and in April he was returned to duty.[3]

However, the observations collected by surgeons in several different wars have shown that there are certain forms belonging to this group of injuries, which are particularly liable to prove troublesome in respect to management, and to be followed by imperfect recovery or physical disability. For instance, Hennen found that "extensive injuries, or the permanent lodgment of balls, gave rise to either death or incurable paralysis."[4] Stromeyer observed that, while shot flesh-wounds of the back did not in general exhibit a special tendency to suppuration, it frequently occurred in long transverse seton-wounds of this region that, their orifices having promptly healed and remained closed, their tracks, months afterward, filled up internally with purulent matter so as to form fluctuating tumors, which had to be lanced, inasmuch as the thick skin of the back was but slowly pierced by ulceration. He likewise remarked: "Many surgeons err in trying to relieve such ailments by several small incisions, or even punctures, parallel to the spine; these afford no relief, and it is absolutely necessary, in such cases, to make incisions several inches in length, at right angles to the spine."[1] It should also be stated, that, if the surgeon does not lay open the track of the ball, in such cases, dame Nature herself will not unfrequently do it by ulceration or sloughing. During the late civil war, I saw several examples of long, seton-like, transverse flesh-wounds of the back, in which the bridge of injured muscle and integument had been completely carried away by ulceration and sloughing, and the seton-like wound itself had been converted into an immense open sore whose long diameter extended transversely, that is, was perpendicular to the vertebral column. The cicatrices resulting from such wounds, as a rule, seriously impaired the functions of the injured muscles. Again, I also saw during the late civil war, several instances of long seton-like flesh-wounds of the dorsal region, which extended between the scapulæ in a longitudinal direction, that is, were parallel to the vertebral column. These wounds had been received by men deployed as skirmishers, while advancing by crawling on their bellies over the ground. In some of them, the missile, having passed through the trapezius, tore for itself a way across the fibres of the rhomboid muscles, dividing them to great extent from above downward, and escaped from the integuments over the latissimus dorsi. In such cases, a considerable degree of disability always remained, owing to the contraction and agglutination of the injured muscles which ensued. Furthermore, Dr. Otis remarks concerning this group of injuries: "There were some curious instances of long, circuitous, ball-tracks; and, among the fatal cases were noted several in which the projectiles had lodged under the scapula."[2] During the late civil war, I several times had occasion to observe that the results were exceedingly unsatisfactory, in all cases of shot flesh-wound of the back, where the missiles lodged beneath the scapula. These patients often complained of having great pain in the injured region, and begged to have the missiles extracted by operations to which they were always ready to submit; the fistulous tracks made by the missiles remained open, discharging purulent matter, while the injured muscles became matted together in consequence of the inflammation and suppuration, and the movements of the injured shoulder always remained much restricted. In one of these cases, after the lapse of many months, the missile which had penetrated above the superior angle of the scapula, and lodged beneath that bone on the inner side of the serratus magnus anticus, sank downward by the force of gravity until it rested on the costal origin of the latissimus dorsi from the last three ribs. It was extracted by making an incision through the integuments and the latissimus dorsi. Thereupon, the patient's sufferings, which had been very great, immediately ceased, and a fistulous channel, which had remained open and discharging, soon became permanently closed; but I do not think that the man ever regained very good use of the injured shoulder.

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[1] I have no doubt that most of these 27 fatal cases of so-called tetanus were, in reality, examples of traumatic spinal meningitis, in which inflammatory irritation of the motor filaments produced tetanic spasms in the corresponding peripheral muscles.

[2] Op. cit., p. 432.

[3] Circular No. 3, War Department, S. G. O., August 17, 1871.

[4] Op. cit., p. 350.

Dr. B. Beck[3] remarks, in substance, that when the fleshy covering of the back is injured, much depends on the depth to which the laceration of the muscles extends, the length of the shot channel, the amount of concussion (as from large shot or shell fragments), and the degree of implication of the ribs or spine. Shot wounds limited to the areolar tissue and muscles mainly, are of no special interest, unless attended by exceedingly large loss of substance, or by a very long, seton-like ball-track. Cases in which bloodvessels of the larger order, and the main branches of nerves, are contused or lacerated, are more serious. The functions of the dorsal muscles are, in some cases, much impaired by shot lacerations. Many invalids of this class are unable to move freely, and complain of difficulty in breathing, stooping, turning the head, etc.; complications due, unquestionably, to cicatrices resulting from lacerated shot wounds that have either been attended by sloughing, or have required incisions to relieve deep suppuration. These observations of Dr. B. Beck confirm those of other surgeons, which have been presented above.

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[1] Quoted by Otis, op. cit., p. 429.

[2] Op. cit., p. 430.

[3] Chirurgie der Schussverletzungen, 1872, S. 448. (Quoted by Otis, op. cit., p. 430.)

Flesh wounds of the back from small-arm missiles, especially when much inflamed, may be attended by paraplegia, as happened in the following case, which Staff-surgeon T. P. Matthew declares "may be accepted as typical of many wounds of this region:—"

> "Maurice Garvey, aged 19, was wounded, on 8th June, by what he supposed to be a spent ball, which struck him on his back about opposite the seventh dorsal vertebra. On admission to his regimental hospital, there was immense swelling of the back, and complete loss of motion of both lower extremities, but not of sensation. The swelling in great measure subsided in a few days, under the use of fomentations, when two wounds were discovered, giving the idea of entrance and exit of a ball, but no injury of the bones of the spinal column could be detected. The wound healed under simple dressings, but the paralysis continued, and he was transferred to the Castle Hospital, on 24th October. Here, under the impression that the persistent paralysis might be due to chronic inflammation of the theca vertebralis, he was twice put under the influence of calomel, with diuretics, and upon each occasion with, it was thought, marked benefit. Subsequently strychnine was given, in sufficient quantity to produce convulsive spasms of the affected limbs. This did not seem productive of any good, and, after persistence in its use for three weeks, it was omitted. He very slowly improved, however, and on 26th January, was invalided to England, having got comparatively fat, and able to stand upon the affected limbs, and even walk a few paces with the help of crutches."[1]

Was the motor paralysis, which presented itself in this case, due to extension of the inflammatory process which arose in the injured tissues of the back, and caused immense swelling inwardly until it reached the theca vertebralis, etc., or was it due to concussion of the spinal cord? This question no one can authoritatively decide, although the fact that mercurials and diuretics proved markedly beneficial on two occasions, decidedly favors the idea that there was a secondary spinal meningitis.

Treatment.—Flesh-wounds of the back made by small-arm missiles should be carefully explored at the outset, and all foreign bodies, including spent balls, fragments of clothing and of equipments, and all coagula, should be promptly extracted. If there be arterial hemorrhage—whether primary, intermediary, or secondary—it must be suppressed by exposing to view the wounded vessel at the place of injury, and ligaturing it on each side of the aperture in its walls. The occurrence of septicæmia, pyæmia, and gangrene, must be obviated as far as possible by applying antiseptic lotions, such as a ten-per-cent. solution of alcohol in water, to which two per cent. of carbolic acid has been added, with a view to increase its efficacy. Drainage tubes should be inserted in all wounds where the purulent matter exhibits a tendency to stagnate, or does not readily flow away. Pain and constitutional irritation should be subdued by administering opiates and sedatives. A nourishing diet should generally be allowed; and, not unfrequently, wine, bitter ale, porter, or alcoholic liquors should also be prescribed. But the most important of all the points concerned in treating this group of injuries, consist in promptly removing all foreign bodies, in dressing the wounds antiseptically, and in draining them thoroughly by passing appropriate velvet-eyed India-rubber tubes of suitable size into them deeply, or completely through them, which is still better. When arterial bleeding occurs in this group of injuries, to such an extent as to constitute surgical hemorrhage, the wounds should not be stuffed with plugs soaked in ferric persulphate or perchloride solutions, neither should these liquids be injected into them, for both proceedings are worse than useless in such cases; on the contrary, the bleeding vessel should be promptly exposed to view at the place of injury, by enlarging the wound itself or by direct incisions, and then it should be tied with two ligatures, one of them being applied on each side of the aperture in its tunics; and, finally, it should be completely divided midway between the ligatures, so that both ends may retract, and thus considerably lessen the liability to return of the hemorrhage. Instructions on this point of treatment are by no means idle or unnecessary, for during the late civil war (as has already been stated) no less than thirty-three fatal cases of secondary hemorrhage from flesh-wounds of the back, inflicted by small-arm missiles, were reported by our military surgeons.[1]

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[1] Med. and Surg. History of the British Army in the Crimea, vol. ii. p. 337.

It is advisable, however, to add that *parenchymatous hemorrhages* from flesh-wounds of the back, when due to occlusion by coagulated blood (thrombosis) of the veins proceeding from the injured part, or to any other cause, must sometimes be treated by covering the raw or granulating surface from which the blood is exuding, with compresses of lint thoroughly wetted with a solution of persulphate or perchloride of iron; but arterial hemorrhages must not be treated in this manner.

Sprains, Twists, and Wrenches of the Back.

The several bones which compose the vertebral column, that is, the true vertebræ themselves, together with the sacrum and coccyx, are united to each other, and to the bones that lie in contact with them, by ninety-nine joints or articulations. All of these joints are more or less susceptible of motion. In some of them, however, the degree of mobility is but slight, as for instance, in the sacro-coccygeal articulation; in others, it is very considerable, as for example in the occipito-atloid and atlo-axoid articulations. The several bones which constitute the vertebral column are likewise strongly bound together by ligaments, a considerable proportion of which are elastic. A brief enumeration of these ligaments may aid us materially to comprehend the effects of sprains, wrenches, and jars of the vertebral column: (1) The lenticular disks of *intervertebral substance*, interposed between the bodies of all the vertebræ from the axis to the sacrum, perform not only the office of ligaments, but they also have elastic properties, which enable them to act in a manner not very unlike that of India-rubber buffers, when placed between the cars of a railway train, in obviating the injurious effects of jars and shocks upon the vertebral column itself, and upon the organs contained in the spinal canal. (2) The *anterior* and *posterior common ligaments* likewise bind together the bodies of the vertebræ. (3) The *ligamenta subflava* gird together the arches of each pair of vertebræ, from the axis to the sacrum. These ligaments are also elastic; and by means of their elasticity, they counteract the efforts of the flexor muscles of the trunk, so that in maintaining an upright position of the vertebral column, they lessen considerably the expenditure of muscular force by their automatic work. (4) The *capsular ligaments* and *synovial membranes* hold together the articular processes of the vertebræ. (5) The *inter-spinous* and *supra-spinous ligaments* fasten together the spinous processes in the dorsal and lumbar regions. (6) The *inter-transverse ligaments* connect the transverse processes of the lower vertebræ with each other.

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[1] Med. and Surg. History, etc., Second Surgical Vol., p. 432.

Furthermore, the *ligamenta subflava* are in direct relation, by both surfaces, with the *meningo-rachidian veins;* and, internally, they are separated from the dura mater of the spinal cord by these veins and some loose connective and adipose tissue. A laceration of these ligaments would probably be attended by a rupture of these veins. Again, the *posterior common ligament* is in relation by its anterior surface, not only with the intervertebral substances and the bodies of the vertebræ, but also with the *venæ basum vertebrarum.* It is in relation by its posterior surface with the *dura mater of the spinal cord*, some loose connective tissue and *numerous small veins* alone being interposed. A laceration of the posterior common ligament would probably be attended by a rupture of these veins, with a rupture of the venæ basum vertebrarum, and a considerable injury of the spinal dura mater. Indeed, the anatomical relations of the ligamenta subflava and the posterior common ligament are such that traumatic spinal meningitis, as well as hemorrhage from the contiguous veins, might readily result from a traumatic lesion involving either of them.

Violent strains and forcible flexures, and strong twists or wrenches of the back, produce injuries of the joints and ligaments of the vertebral column, and of the adjacent parts, both soft and hard, which are strictly analogous to the lesions that result from the same kinds of hurt when they affect the joints of the extremities. The lesions which are met with in the back, in consequence of these forms of injury, vary from a slight laceration of some fibres of the vertebral ligaments, and of the contiguous connective tissue, and lesser bloodvessels, on the one hand, all the way up to a very extensive tearing through or detachment of the vertebral ligaments, with a correspondingly extensive rupturing of the contiguous muscles, tendons, connective tissue, and bloodvessels, on the other. Indeed, the lesions which result from severe sprains and twists, or wrenches of the vertebral column, differ only in degree from those which attend dislocations of the vertebræ. But, according to the observations of Mr. Hilton, "the most frequent lesion in injury to the spine is a partial severance of the vertebra from the intervertebral substance."[1] This view receives support from the fact that the junction of a more to a less elastic body is the weakest spot, and, therefore, receives the full effect of a strain.[2]

The *symptoms* or phenomena which attend these accidents are pain in the injured parts, and inability to move them, with tumefaction and tenderness under pressure in the same region; and, not unfrequently, subcutaneous ecchymosis appears in the swelling. These symptoms, however, all vary in degree and extent, according to the amount of the injury that has been sustained. The swelling may or may not be attended by ecchymosis; and sometimes the latter does not make its appearance for several days. The tenderness under pressure is usually not restricted to the spinous processes of one or two of the vertebræ (which circumstance, if it were present, would excite a suspicion that vertebral fracture existed), but is equally noticeable over several contiguous spinous processes. At the same time, on tracing the tips of these spinous processes, they are found to be in a normally straight line, and on a proper level. So much at present concerning the immediate effects of these accidents.

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[1] On Rest and Pain, Am. ed., pp. 47, 48.

[2] Ibid., p. 48, foot-note.

Among the remote effects of the lesions of the back, especially when they have been neglected or improperly treated, are permanent lameness of the back from chronic inflammation of the injured joints, and curvature of the spinal column from vertebral caries. Mr. Hilton thinks that severances of the vertebræ from the intervertebral substances, when inadequately treated, are particularly liable to give rise to vertebral caries.[1]

Among the possible consequences of sprains or wrenches of the vertebral column, spinal meningitis must likewise be mentioned. The following statement concerning a case, in which a wrench of the back was received while on board of a street railway car, has recently been printed, on apparently good authority, in a prominent morning paper in New York:—

> "As one turns into Sixteenth Street off Union Square, on the west side, one notices the tan-bark laid thickly in front of a handsome house in the middle of the block. Here lies G. G., the popular soubrette of the Théatre Comique. She stopped a car a few weeks ago, and the conductor started it before she had fairly got on, giving her such a wrench and start that she felt at the time a severe pain in her back. From that day to this she has been unable to move, lying dangerously ill with spinal meningitis."[2]

Sprains, Twists, and Wrenches in the Cervical Region.—No other cases of spinal injury or disease are so immediately dangerous to life as those in which the upper part of the cervical region is the seat of injury, but especially the first and second cervical vertebræ, or the space between them; for, when spinal paralysis results from injury or disease of this part of the cervical region, the nerves which cause the respiratory muscles to act are likewise paralyzed, and then complete stoppage of the respiratory movements, or death, instantly ensues. Mr. Hilton has reported a number of cases which give so much information of very great value to both surgeons and patients concerning this group of injuries, especially about their symptoms, consequences, and treatment, that my work were but illy done should I omit to mention them. Concerning a case where death from pressure upon the spinal marrow was impending, which ultimately ended in recovery, he says:—

> "In 1850, I was requested by Dr. Addison to see, with him, a young woman, suffering from injury in the upper part of the spine, the result of an accident. I found her almost pulseless, with great distress in breathing, loss of voice, inability to swallow, and nearly complete paralysis of the arms and legs. She had had, from the early part of her illness, severe pains spread over the back of her head and neck, increased on pressing the head downward upon the spine. Her symptoms had gradually arrived at this stage of danger, without benefit of medical treatment. I might here say, that the difficulty of breathing and deglutition had so greatly increased of late, that it was thought necessary, or to her advantage, to lift her up more and more in the bed; but the change of posture seemed only to add to her distress in breathing and swallowing. These were the difficulties for which my assistance was requested. She was then propped up in bed by pillows at her back, with her head inclined somewhat forward, or dropping upon the chest. As the impediment to swallowing was almost an insurmountable difficulty, I was desired to examine the throat, but I could not discover anything wrong in it. It was our opinion that her life was in imminent, or perhaps, instant danger. She was paralyzed, and could not swallow; her voice was excessively feeble, and her pulse not very perceptible; she scarcely breathed at all, and was not quite conscious. It was evident that something must be done without delay. Believing that her symptoms resulted from the odontoid process of the second vertebra pressing upon the spinal marrow, close to the medulla oblongata, I advised that she should be made to lie down immediately. On saying to her, 'You must lie down in bed,' she

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[1] Ibid., p. 48.

[2] N. Y. Sun, June 4, 1882.

replied, in the smallest possible voice, 'Then I shall certainly be killed; I can't get my breath.' Seeing there was no time for contention, I told her our opinion was, that, if not placed longitudinally in bed, she would in all probability die in a very few minutes. Being paralyzed, or nearly so, she could offer no resistance to my purpose; and I shall never forget the weight of the responsibility, when I took hold of her, desired the pillows to be removed from her back, and, supporting her head and shoulders in my arms, slowly placed her upon her back, nearly flat upon the bed, with her head upon a thin pillow, some additional support to the hollow of her neck, and two sand-bags, one on each side of her head, to prevent any lateral or rolling motion. Here was a patient in the greatest possible danger, and I do not hesitate to express the opinion, that, if the head had fallen forward, say half an inch, she would have died in an instant. Her sense of suffocation was soon relieved by the horizontal position, and she remained lying down during six months uninterruptedly, at the end of which time all the serious symptoms had disappeared. She was then allowed to move about the ward, with caution; and, a few months afterward, left the hospital, well, with the exception of a stiff neck, most probably depending on anchylosis, or bony union, between the atlas and the axis. In this case, nothing but complete rest was employed as a remedy; rest was the only element of success in the treatment, and I think it is a very striking example of its power to prolong life, by enabling Nature to repair her injuries undisturbed."[1]

In this case, the sprain or wrench of the joints between the atlas and the axis was followed by chronic inflammation of these joints, of a destructive character, which, happily, terminated in a cure by anchylosis, under the benign influence of prolonged rest. The severe pain over the back of the head and neck, which helped to mask the vertebral lesion, for some time, was due to irritation of the occipitalis major and minor nerves, and, perhaps, of other branches of the anterior and posterior cervical plexuses of nerves, also.

Mr. Hilton continues in a most instructive vein:—

"I will now direct your attention to another case of diseased cervical vertebræ (also caused by a hurt), which terminated in sudden death. It is that of a little child, five years and five months old, seen by me in 1841. She was a small, delicate, unhealthy girl. She had been accustomed to ride a good deal in the country, with her mother, in an open carriage, and was thought, in that way, to have caught a cold in the back of the neck, which became gradually stiff and swollen, accompanied by pains in the head and neck. These pains were believed to be rheumatic, and the treatment employed had reference only to that impression, which was supposed to be supported by some pain experienced in the limbs, with cramps and stiffness in walking. She frequently suffered from fever and loss of appetite, and had been under medical treatment during many weeks, the symptoms slowly increasing in severity. The mother told me afterward that she had thought her an obstinate child, and that she sometimes threatened to punish or to shake her well because she would not take her food. I have no doubt, if she had done so, she would have killed the child. Upon careful examination, I thought I made out the case to be one of disease between the first and second cervical vertebræ, or thereabouts. I say thereabouts, because the parts were too much swollen, and too painful, to admit of a more accurate local investigation. There was pain at the back part of the head, in the course of the great occipital nerve; pain behind the ear, in the course of the great auricular, and of the small occipital; pain in the higher part of the neck, on rotation of the vertebræ upon each other; and pain in the same vertebræ, probably the first, second, and third, by pressing the bones upon each other. She had some difficulty in deglutition, and the voice had lately changed its character, and become more feeble, indicating that the pneumogastric nerves, and possibly the spinal accessory, were involved in the mischief. Thus, having, in common with the surgeon in attendance, recognized the real nature of the case, directions were given that the child should be placed upon her back, with her head resting upon a thin pillow, and some additional support to the nape of the neck, each side of the head to be supported by sand-bags, so as to prevent any lateral or rotary movement in the neck. It was plain that, if the life of the child was to be prolonged or saved, it could only be accomplished by a long-continued rest to the spine; and, for the purpose of securing easy rest to the little patient, a water-bed was sent from London, and the child was safely placed upon it, with the sand-bags extending from the shoulders to beyond the head. In about a fortnight the nurse specially appointed to attend the child, finding that her rest at night was now so calm and quiet, that she was so free from pain and fever, that her appetite and power of swallowing were so much improved, as well as her temper, and thinking she was altogether so much better, and willing, no doubt, to mark her own penetration, as well as to please the mother by telling her in the morning what had been done by her little charge—this meddlesome and officious woman, instead of giving the child her breakfast, as usual, without disturbing her head or neck in the least degree, desired the child to sit up to breakfast. The child did so; the head fell forward, and she was dead. The *post-mortem examination* proved that disease existed in the articulations between the first and second cervical vertebræ, that the bones were loose, and that, when the head with the atlas fell forward, pressure had been made upon the spinal marrow, close to and below the medulla oblongata, at the point of decussation, so that the child was killed almost instantly, as in pithing animals. This was a case in which both the surgeon and nature were completely thwarted. The local disease was considered at the time to be dependent upon a constitutional or a scrofulous cause; but I have since understood that it was the result of a blow given to the little girl by her brother, who struck her with something he had picked up in the room. It was not constitutional; there was no visceral disease of any kind."[1]

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[1] Op. cit., pp. 60, 61

In this case, then, there was a destructive inflammation of the joints between the atlas and the axis, arising from a blow upon, or a wrench of, these joints, and the real character of the lesion was, for a long time, overlooked; but, in all probability, it would have been cured, as the preceding case was cured, by proper and long-continued rest, had nature and the surgeon not been thwarted by the misadventure. Moreover, the morbid condition of the atlo-axoid articulations, which was revealed by the autopsy, in this case, sheds a flood of light upon the pathogenesis of the preceding case, and frees it from all obscurity or doubt. Thus, the history of this case is the complement of that of the preceding case, and fully elucidates it.

Mr. Hilton also relates the case of a lady, aged about 30, who had a disease of the spine affecting the occipitalis major and minor nerves, the third cervical nerves, and the nerves forming the left axillary plexus, that was caused by a blow on the left side of the head with a bolster, or cushion, which forcibly displaced it laterally, and thus strained or wrenched the joints of the first, second, and third cervical vertebræ. She fell upon the carpet, and was unconscious for some little time. She had, as reported to herself, a sort of struggling fit. On recovery, she was put to bed; and, in a day or two, nothing remained of the accident, excepting some tenderness in the upper part of the neck; but, soon afterward, the symptoms about to be described came on. When Mr. Hilton first saw her, some nine or ten months after the injury, "she had pains on the left side, at the back of the head, and at the posterior part of the external ear; pain over the clavicle and shoulder (all on the left side); pain, with loss of power, in the left arm; pain deep in the neck, on pressing the head directly downward upon the spine, and on rotating the head; some fulness and tenderness on pressure about the first, second, and third cervical vertebræ, especially on the left side. She could not take walking exercise in consequence of the increasing severity of all the symptoms. She had almost sleepless nights, and her appetite was very poor. It was obvious that there existed some disease or injury of the spine affecting the occipital nerves, the third cervical nerves, and the nerves forming the left axillary plexus. As far as I [Mr. Hilton] could interpret the case, rest appeared to be the proper remedy. The patient maintained, almost uninterruptedly, the recumbent position, during nearly three months, two sand-bags being placed one on each side of the head. The only medicine employed was one-sixteenth of a grain of bichloride mercury twice a day, during about two months. At the expiration of three months the patient had lost all pain and tenderness, and had regained the use of the arm, neither did pressure nor rotation of the head induce pain. The fulness in the neck had also disappeared."[1] To conclude the case, this lady left town, and, afterward, reported herself quite well, being perfectly cured.

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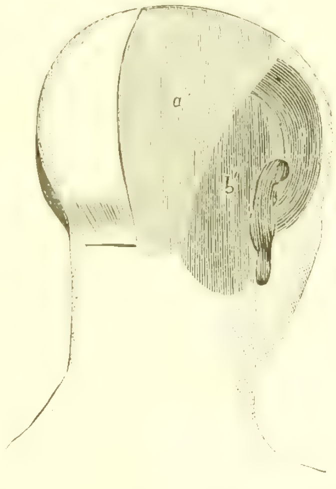
[1] Ibid., pp. 61, 62.

The wrench of the vertebral column, in this example, appears to have been attended with cerebral concussion, caused by the same blow on the head which produced the sprain of the neck, and there was loss of consciousness for some little time. She was placed in bed, but she was not kept there long enough for the injured joints connecting the first, second, and third cervical vertebræ together to become sound again. The consequence was, that, as soon as she got up and began to go around, the inflammation in the sprained joints increased, the contiguous sensory nerves became irritated thereby, and pains appeared in the parts to which they were distributed, that were mistakenly considered to be rheumatic pains; and so the poor lady went on for nine months, constantly under treatment for rheumatism and hysteria, but getting worse the whole time. Rest, that is, enforced quietude of the injured articulations, was the sole means of importance, which finally secured her recovery; and the same means, had it been applied to her case at the outset, for only a few weeks, would have saved her from a year of intense suffering.

"The next case is that of a surgeon," writes Mr. Hilton, "who was in the yacht of another gentleman. Running along from one part of the ship to another, he struck his head against the top of a door, and was thrown backward with great force. Very shortly afterward he had pain in the distribution of the occipital nerves at the back part of the head and the back of the neck. [See Fig. 770, *a*, *b*.] Six weeks from that time (he still continued in the yacht), having experienced some increase of pain, and heard and felt a grating sensation in his neck, he was somewhat alarmed, and came to me, suffering from pains indicating disease of the second or third cervical vertebra. He was ultimately cured by lying down—that is, by rest. On the 8th of February last he came to me perfectly well, and says he was quite cured by *rest*. Time will not permit me to dwell on the details of this surgeon's case."[2]

In order to illustrate the varieties in strains of the neck, together with the symptoms and treatment of recent cases, the following examples must be briefly presented:—

Fig. 770.



Showing, *a*, the portion of the scalp supplied by the occipitalis major nerve; *b*, the portion supplied by the occipitalis minor nerve; *c*, the porton supplied by the auriculo-temporal nerve. (Hilton.)

A young carpenter, while stepping backward, tripped on a heap of planks, and fell upon his back. His shoulders were received on the planks; but, his head and neck projecting beyond them, the neck was abruptly bent backward with much force. Swelling at the back of the neck, from occiput to scapulæ, so great as to be visible at a distance, appeared soon after the accident. He was unable to keep his head erect; and before attempting to do so, placed a hand on each side to steady it. He was placed in bed. At the end of a month, having been provided with an artificial support, he was made an out patient.[3]

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[1] Ibid., pp. 54, 55.

[2] Ibid., pp. 55, 56.

[3] Holmes's System of Surgery, 2d ed., vol. ii. p. 359.

Again, a shoemaker, aged 32, while stooping, tripped and rolled over, with his head under him. His neck received thereby a twist that caused much pain. He lay motionless, flat on his back, for ten minutes, being without the power to move both arms and legs, and having a sense of numbness and of pricking throughout the body. In trying to stand, his legs gave way under him, as if he were intoxicated. Sensation, also, was impaired but not lost. Within twelve hours, however, both motor power and sensation were restored; and the paralysis did not return. He complained of acute pain in the neck, which was aggravated by the slightest movement of the head; and he, therefore, kept the head perfectly still. He lay in bed, on his back, with his neck sunk on to a low soft pillow, and propped up by sand-bags. On examination, the chief tenderness was found at the fourth cervical vertebra; and there a deeply seated swelling was perceived. For treatment, absolute rest of the neck was enforced, and tincture of iodine applied. In a month he was allowed to leave his bed, with his head supported by a plastic shield extending from the shoulders to the occiput. He could then perform the nodding, but not the rotatory, movements of the neck. In nine weeks, all the cervical movements seemed quite restored; but, for precaution's sake, he was kept in hospital three weeks longer. He returned to his trade, and called several times afterward to show that he was well.[1]

Finally, a little, ricketty girl, of 3 years, having a large head, was admitted to hospital, late one evening, with paralysis of the upper and lower extremities. She had fallen out of bed, that morning, head-foremost, and was insensible for a few minutes. During the day, it was remarked that she did not get upon her feet, nor move her legs; and that she did not use her hands. When examined, motor power was found to be lost in both upper and lower extremities. She showed no signs of pain when the skin was pricked anywhere below the upper part of the chest. Reflex movements were excited in the lower extremities when the skin of the abdomen, and it alone, was pricked; and then the child gave a slight cry of pain; respiration natural; bladder and rectum not affected. She uttered cries whenever the neck was moved, or the back of it was pressed on by the fingers; and, after it, seemed pleased to keep the head at perfect rest on a pillow. For three days no change in the symptoms was observed; on the fourth day there were visible signs of improvement; on the fifth, it was discovered that she could freely move both upper and lower extremities, and that motion of the head had ceased to give pain. There was no further trouble, and she remained quite well.[2]

The main point in the treament of recent, as well as in that of old cases, in which the articulations of the cervical vertebræ have been sprained or wrenched, is to maintain them in a state of complete immobility and relaxation until the cure is complete. To this end, the patient must be made to lie continuously in bed, on the back, with only a thin pillow under the head, and barely enough support under the nape of neck to keep it from sinking. Besides, to keep the head straight, and to prevent its rolling from side to side, sand-bags, that are sufficiently long and heavy to fulfil the indications, must be so placed upon the patient's pillow, one on either side of the neck and head, as to give both of the parts a complete lateral support. Indeed, I do not know of any other mechanical expedient, of a simple nature, which answers this purpose as well as sand-bags, made of bed-ticking, of a length sufficient to extend beyond the head, and about three-fourths filled with dry sand. One of them is to be placed with care on each side, close to the neck and head, and is to be accurately moulded thereto, so as to keep the head entirely straight, and to render all lateral or rotatory movements of the parts impossible.

SPRAINS, TWISTS, AND WRENCHES IN THE DORSAL REGION.—The dorsal portion of the vertebral column, when compared with the cervical and lumbar portions, is characterized by a relatively much greater rigidity and want of flexibility or capacity for movement upon each other of the several bones that compose it, at the articulations by which they are linked together. The injuries caused by sprains and twists, or wrenches, in this region are, therefore, somewhat analogous to those produced by enormously powerful blows, and their deleterious effects are apt to be restricted to the articulations which connect two contiguous vertebræ, instead of being dispersed or diffused so as to affect the articulations of many adjoining bones, as is usually the case with similar injuries in the more flexible parts of the vertebral column, the cervical and lumbar regions.

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[1] Ibid., p. 359.

[2] Ibid., pp. 359, 360.

There is a traumatic, as well as a rheumatic, "crick" in the back, which is not unfrequently caused by lifting, or attempting to lift, a heavy weight while in a stooping position, and is located in the dorsal region. The victim, while exerting his strength to the uttermost in this position, suddenly feels "something give way" in his back, and is soon seized by cramping pains in the affected part, which are aggravated by all attempts to produce motion therein; so that he carefully abstains from making such attempts himself, and is only too glad if the injured part be allowed, by the exigencies of life, to remain in a state of absolute quietude. In such cases, the muscular fibres belonging to the strained part are sometimes lacerated to a considerable extent, and the effusions of blood and of inflammatory products into the injured muscular and connective tissue may cause tumefactions, possibly with subcutaneous ecchymoses also, which can readily be felt and seen externally. For such cases, the best plan of treatment consists in the enforcement of absolute quietude as long as the soreness continues, with the external use of a mildly stimulating liniment, and the internal administration of opiates, whenever necessary to allay the pains.

Sprains and wrenches of the dorsal part of the vertebral column are sometimes caused by alighting on the dorsal region in falls, or when thrown from the saddle while on horseback. They are also produced, occasionally, in military life, by the trampling of horses upon the backs of men who have suddenly been dismounted, or have been thrown down to earth by other means, in battles or in sham-fights.

The vertebral ligaments and joints may likewise be sprained or wrenched by the impact of powerful blows on the dorsal region, no matter what the instrument may be that inflicts them. In respect to treatment, no additional directions are required.

The natural curvature of the dorsal part of the vertebral column, the convexity of which looks backward, undoubtedly exerts considerable influence in the way of lessening the injurious effects upon the vertebral ligaments and articulations, of violent blows on the dorsal region. This circumstance probably explains why it is that heavy blows on this part of the back are so seldom attended with strains or wrenches of the vertebral column, that prove troublesome to manage, or even require a surgeon's care. The principal effect of strong blows, etc., when received on the convexity of the vertebral arch in the dorsal region, is to compress the intervertebral substances, and the articulations in general, which enter into the formation of the arch; and, therefore, they usually do comparatively little harm to the spine. But a much more powerful blow—one, for instance, that falls but little short of dislocating or fracturing a dorsal vertebra, and so comes very near to breaking down the dorsal arch—may readily detach the corresponding intervertebral substance, to greater or less extent, from the bone, and thus cause an inflammation which may prove destructive to the injured bone and cartilage, especially if the lesion chance to pass unrecognized, or happen to be inadequately treated. It is not improbable that caries of the dorsal vertebræ sometimes begins in this way.

The mechanical effects of falls, however, are widely different from those of blows on the dorsal portion of the vertebral column, especially when the victim's back happens to alight upon some solid body of comparatively small dimensions, whose upper surface is considerably raised above the surrounding ground—for instance the stump of a tree, or a block of wood, etc.; for, in such a case, when the further descent of the back is stopped by striking against the solid body, the downward movements of the head, neck, and upper extremities on the one hand, and those of the abdomen, pelvis, and lower extremities on the other, are not arrested at the same instant of time as that of the dorsal region; and, therefore, the weight and impetus of these parts simultaneously press downward, with great energy, upon both the upper and lower ends of the arch formed by the dorsal vertebræ, and on the concave side thereof, in such a manner that the intervertebral substances and bodies of the dorsal vertebræ are in the line of extension, and the spinous processes of these vertebræ in that of compression. It is obvious that a comparatively slight fall upon the dorsal region, occurring in this way, may badly stretch or strain the anterior and posterior common ligaments of the spine, and may also separate to a considerable extent the intervertebral substances from the bones. It is highly probable that caries of the dorsal vertebræ, in consequence of falls upon the back, not unfrequently originates in this manner; and that comparatively trifling accidents of this sort may, under favoring circumstances, suffice to produce this result.

SPRAINS, TWISTS, AND WRENCHES IN THE LUMBAR REGION.—The vertebral column is sprained and twisted, or wrenched, in the lumbar region, more frequently than in any other part thereof. Such lesions of the lumbo-vertebral articulations are sometimes produced in attempting to lift great weights while in a stooping position; and by the impact of blows and falls upon the lumbar region itself, quite analogous to those in the dorsal region which have just been discussed. More often, however, they are caused by accidents in which the vulnerating force is indirectly applied to the lumbar region; for instance, by alighting on the buttocks in falling from a height, or by the falling of a heavy weight upon the head or upper part of the body, while it is in an erect posture, the lower extremities being firmly planted on the ground. Many years ago, a good example of the first-mentioned kind of accident came under my observation:—

A young farmer, aged about 20, accidentally slid down from a steep hay-mow, and then falling about fourteen feet, struck the ground upon his buttocks. He received thereby a violent jar in the lumbo-sacral region. His head and shoulders sank backward to the earth, where he lay for some time, unable to arise, barely able to move his legs a little (they also felt benumbed), and suffering terribly from pains in both lumbar regions. At first, he thought his "back was broke." However, after he had lain wet with cold sweat for some little time, he began to feel less faint, or a little stronger, and found himself able to move his lower extremities rather better. The pains, too, gradually abated, and then turning himself partly over, he tried to make his way to the house by crawling on his belly; but these efforts increased the lumbar pains so much that he was compelled to desist. After lying quite still, a little longer, he found that the paralysis of his lower extremities was considerably lessened, and that possibly he might arise. After many efforts he succeeded in doing so, his legs, meanwhile, having given way under him several times like those of a drunken man. He walked with the feeble and uncertain steps of an intoxicated person, from the weakness of his lower limbs; but after much effort, he succeeded in getting to the house, a distance of about two hundred yards, without any assistance. He was immediately placed in bed. There was considerable swelling across the loins, and much tenderness was discovered by pressing upon the lumbar spinous processes. Tenderness was also discovered in and around the bodies of the last three lumbar vertebræ, on pressing upon them through the front wall of the abdomen. There was no displacement of the bodies or spinous processes of the vertebræ. For several days, the loins were fomented with a strong decoction of chamomile flowers and wormwood. His favorite posture in bed was that of lying upon the side (it did not seem to matter which side), with his body semi-flexed, and knees drawn up. For many days he was reluctant to make any change whatever in his posture, because of the excruciating pains in the lumbar region, which every little twist or flexure of the injured articulations of the spine, and every contraction of the lumbar muscles, gave rise to. As continuous confinement to bed was enforced, the first important evidence that he was recovering was noted when he began to move himself about in bed, of his own accord. On discontinuing the fomentations, a large belladonna plaster was applied to the loins. He was confined to bed just four weeks, and the complete rest of the injured parts, thus secured, was the chief means relied upon to promote his recovery. He wore belladonna plasters, and complained of feeling lame and weak in the lumbar region for a long time afterward ; but, in the end, he perfectly recovered.

In this case, the articulations of the lumbar vertebræ were wrenched in a peculiar manner. The young man's buttocks, in falling from a height of fully fourteen feet, struck the ground with great force. At that instant, the lower part of the spinal column was suddenly compelled to support the weight and impetus, or momentum, of all parts of the body situated above the loins, the first effect of which was to compress the intervertebral substances, to be followed, however, in an instant afterward, by a violent bending of the spinal column backward, at the peculiar curvature formed by the lumbar vertebræ on top of the sacral curvature. The greatest part of the strain, therefore, fell upon the articulations of the last three lumbar vertebræ ; and, at the same time, the intervertebral substance and the bodies of these vertebræ were in the line of extension. In this way, the anterior and posterior common ligaments of the spine, and the intervertebral substances, in the lumbar region, together with the psoas muscles, were all severely stretched ; and this circumstance accounts for the fact that much tenderness under pressure was discerned on examining the lumbar vertebræ through the front wall of the abdomen. The nature of the lesion also explains why it was that the attempt to crawl on the belly caused so much increase of the pains in the injured part ; for, on elevating the shoulders in order to execute the movements which constitute crawling, the injured vertebral ligaments and muscles were again put on the stretch.

A good illustration of the last-mentioned kind of accident, in which the vulnerating force is indirectly applied to the lumbar region, was lately under my care :—

E. B. C., aged about 60, while walking in the second-story hall of an old house, January 21, 1882, entirely oblivious of danger, was suddenly struck on top of the head by a mass of plastering, estimated to weigh over two hundred pounds, that, having become loosened, had fallen down from the ceiling, which itself was rather lofty, being about sixteen feet high. The blow on the head, of course, was exceedingly violent ; it gave him a scalp-wound two and one-half inches long over the right parietal bone, with severe concussion and contusion of the brain. His body was also bent forward, and doubled up, by the force of the blow on the head and the weight or momentum of the falling mass of plastering, so that he was instantly crushed down to the floor, where he lay stunned for some little time. The forcible bending forward and doubling up of his body took place at the loins ; and thus the lumbar muscles and the articulations of the first, second, and third lumbar vertebræ were badly strained. Obviously, the structures of the forepart of his spinal column suffered powerful compression at the place of forcible flexure, while those at the back-part thereof were subjected to violent elongation and overstretching. The cerebral lesion masked to a great extent the subjective symptoms of the lumbar lesions, for a considerable time ; but, objectively, there soon arose a swelling across the injured loins which attained the thickness of a man's hand, was very tender under pressure, and lasted a long time. The quietude and other remedial measures that the cerebral contusion demanded, were sufficient to relieve the lumbar lesions also, so that no special medication was ordered for the lumbar region until April 12, when a large belladonna plaster was prescribed, giving much relief. His recovery, however, was not complete (as to the loins) until the 1st of June.

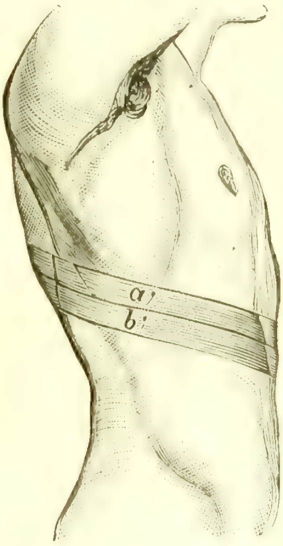
Usually, considerable swelling across the loins soon follows such injuries of the lumbar region as have just been described. Subcutaneous ecchymosis may or may not attend the tumefaction. Sometimes the ecchymosis does not appear until several days after the accident. On tracing the spinous processes with the fingers, their positions are found to be the same as in the normal state. On examining the bodies of the lumbar vertebræ through the anterior wall of the abdomen, no displacement is detected. Tenderness under pressure, in such cases, is usually observed over a considerable space. Oftentimes the patient, with evident difficulty, and much exhibition of pain and weakness in the loins, will endeavor to place his vertebral column in an erect position; if his efforts be successful, and no deformity be presented, it may confidently be assumed that there is no fracture. The posture which patients having lumbar sprains generally assume in bed, is, as described above, that of lying on one side, with the trunk semi-flexed, and the knees drawn up; and, for many days, they are usually reluctant to make any change of position, from dread of the pains and spasms in the injured muscles, which all attempts at movement are liable to excite. When such patients begin to move themselves about in bed, of their own accord, they furnish the best possible evidence of progress toward recovery.

The *treatment*, as shown above, does not differ essentially from that of sprained joints in general. The most important point is to enforce absolute quietude of the injured parts for a sufficient length of time. Commonly, it requires from four to six weeks' confinement to bed for recovery to take place. If the bowels be at all confined, a mercurial purge may be administered with advantage. If there be febrile movement of a sthenic character, saline drinks may be given with benefit, and the diet should be low while it continues. Should the lumbar pains or the muscular spasms prove troublesome, they may be quieted by exhibiting opium in the form of Dover's powder. The diet must be nourishing in asthenic cases, and in all others likewise after the acute stage has been passed. Fomentations with decoction of poppies, applied to the injured loins, also appear to do good. But those which consist of a strong decoction of chamomile and wormwood (mentioned above), are perhaps still better. At a later period, camphorated oil, or camphorated soap-liniment, should be used instead of fomentations. The patient, when about to leave his bed, should be furnished with a riding-belt stiffened with additional whalebone. (Shaw.) At the same time, a large belladonna plaster can generally be applied with benefit.

INFLAMMATION OF THE VERTEBRAL ARTICULATIONS ARISING FROM SPRAINS, TWISTS, OR WRENCHES.—From such injuries, an inflammation of the overstretched or lacerated ligaments, tendons, muscles, and connective tissue, more or less severe according to the nature of the case, soon ensues. This appearance of inflammatory reaction in the damaged tissues is a necessary consequence of the original lesions. Its occurrence should, therefore, be anticipated, and its treatment should likewise be provided for by the surgeon from the very outset of the case. Moreover, this traumatic inflammation may, in general, be completely controlled by patiently applying the principles and methods of treatment just enunciated. But when the presence of traumatic inflammation in the vertebral joints happens, from any cause, to be unrecognized, or, if recognized, to be made light of, and when, therefore, the disorder receives no treatment whatever, or at best is very inadequately treated, then the inflammatory process is quite liable to become chronic and suppurative in character, and, in the end, to destroy the vertebral articulations involved, just in the same way as the joints of the extremities are detroyed by disease under similar circumstances. It is this chronic or consecutive disorder of the vertebral articulations, that not unfrequently results from sprains and twists, or wrenches, of the vertebral column, which we have now to consider. It is, perhaps, more often met with in cases where the symptoms of injury originally are not severe, than in cases where they are strongly marked; for, in the latter instance, the severity of the symptoms themselves will be apt to secure that thoroughness and sufficiently long continuance of treatment which is indispensable for recovery. However this may be, it nevertheless is certain that this disorder not unfrequently appears in cases where the symptoms of vertebral injury have been originally by no means severe; and sometimes, too, in cases where the symptoms of vertebral injury have been comparatively slight at the outset, so that the disastrous consequences have unexpectedly ensued. When the articulations of the spine that have been damaged by sprains, etc., are occupied by chronic inflammation, they are liable to exhibit at first gradually increasing tumefaction and induration; then indolent suppuration, like that which takes place in other joints that are similarly affected, and, finally, ulceration of the cartilages and caries of the vertebræ.

Among the earliest symptoms in these cases, not unfrequently, are pains, located not in the spine itself, but in the parts supplied by the terminal branches of the sensory nerves which issue from the vertebral column at the seat of the lesion, and give rise to the pains, because their filaments are irritated by the inflammatory process going on in the intervertebral foramina through which they pass. Several examples have already been presented where disease of this sort, situated between the first and second cervical vertebræ, was attended by pains located on the back part of the head, behind the ears, etc., because the occipitalis major and minor nerves with the auricularis magnus were irritated in this manner within the spinal column (see Fig. 770). In such cases, the pains due to the spinal disease are apt to be mistaken for rheumatic pains, and to be maltreated accordingly. In like manner, pains at the pit of the stomach may be caused by diseases of the dorsal vertebræ, which irritate the sixth and seventh dorsal nerves (see Fig. 771). Mr. Hilton presents two examples which well illustrate this point. Both patients, however, made good recoveries, by adopting rest as the chief remedial agent, and without applying anything to the dorsal region.[1] Mr. Hilton also points out that these pains are almost always symmetrical, that is, alike on both sides of the median plane, when they arise from disorders in the lower cervical, dorsal, or lumbar vertebræ, whilst they often are uni-

Fig. 771.



Side view of the chest and abdomen, showing the course of the sixth and seventh dorsal nerves. (Hilton.)

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[1] Op. cit., pp. 48–50.

lateral, or one-sided, when caused by disorders between the occiput and the atlas, or between the atlas and the axis. The most probable explanation of this peculiarity is, that a spinal disorder occurring between the occiput and the atlas, or between the atlas and the axis, may be confined to only one of the joints between these bones, whilst a disorder of the lower cervical, dorsal, or lumbar vertebræ, generally involves the bodies of the vertebræ or the intervertebral substances, entirely or completely.[1] I have, however, lately seen a case wherein pains of this sort, that were caused by chronic inflammation following a wrench of the lumbar vertebræ, appeared on one side only.

The following case, which is related by Mr. Hilton, illustrates the symptoms of this lesion, when it involves the eighth and ninth dorsal vertebræ, in a most useful manner:—

It is that of a moderately robust little girl, aged 4½ years, who, while enjoying good health, fell down out of bed upon her back, a distance of about two feet. But nothing appears to have been thought of it at the time, though she at once began to lose flesh, and her face become anxious. About three months afterwards, she began to complain of symmetrical pains in her belly, was easily fatigued also, and stooped a little in walking. Her fall upon the back having been forgotten, she was treated for the abdominal affection by several surgeons, but rapidly grew worse instead of better. She became much reduced in flesh and strength, and unable to walk about, from spasmodic pinching pain in the abdomen, which "doubled her up." In a short time, however, having been kept quiet in bed, she recovered her flesh and strength, so as to be enabled to walk about a little without pain. But, quickly, all the untoward symptoms again supervened; the abdomen became large and tumid, the bowels irregular, with pain in the belly, as if a cord were drawn tightly around the abdomen and tied. Another surgeon was now consulted, who declared the mesenteric glands affected. The urine was phosphatic and ammoniacal. She was allowed to go about as usual. In a short time the alteration and unsteadiness of gait became more marked, and, the other symptoms continuing, she was taken to London for advice. Disease of the eighth and ninth dorsal vertebræ was detected, with slight projection backward, or angular curvature. Her fall upon the back had recently been remembered. Uninterrupted rest in the recumbent posture was ordered, with no medicine, and the child completely recovered in four or five months.[2]

It is apparent that in this case the real cause was, for a long time, entirely overlooked; that the abdominal symptoms were treated as depending on some error in the abdominal viscera, when they wholly depended on the spine; and that the spinal condition itself was meanwhile altogether ignored. Nevertheless, almost all the symptoms which attend chronic inflammations of the vertebral joints, in consequence of neglected sprains and wrenches, were present in this case. For example, there were pains in the belly, which were due to irritation of the sensory filaments of the ninth pair of dorsal nerves. There were also cramps or muscular spasms in the belly, which were caused by irritation of the motor filaments of the same pair of nerves, during their passage through the intervertebral foramina. Besides, there was paraplegia (incomplete), which probably resulted from compression of the spinal cord. The urine, too, became phosphatic and ammoniacal, and the bowels tympanitic, in consequence of accompanying myelitis. Moreover, the appearance of angular curvature of the spine, at the seat of injury, served to show exactly what joint was sprained, and the nature of the disorder which invaded the bodies of the contiguous vertebræ in consequence of the articular lesions. By adding to this account of the symptoms, a statement that tenderness under pressure and some swelling of the soft parts were found over the eighth and ninth dorsal vertebræ, which without doubt was the case, a complete picture of the symptoms pertaining to the disorder in question is presented. So much, then, for the symptoms which are liable to result from traumatic spinal arthritis, when it becomes chronic and advances unchecked for some considerable time; or until caries of the bodies of the contiguous vertebræ ensues.

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[1] Ibid., pp. 51, 52.

[2] Ibid., pp. 52, 53.

Caries of the vertebræ, however, will not be specially discussed in this article, as it will be fully dealt with elsewhere. Inflammation of the vertebral joints is here considered only in so far as it is a consequence of sprains and twists or wrenches of these joints, and in so far as it becomes necessary for surgeons to thoroughly understand the symptoms, final results, and treatment of these hurts, in order to recognize their importance, and take care of them in such a manner as to save patients from the great evils which, when neglected, they are liable to cause. To this end I have presented the foregoing examples and observations that illustrate these forms of injury, and the principles which should guide their treatment. It is necessary, still, to point out briefly some direful consequences of these lesions which have not yet been mentioned, and which are as follows: (1) The consecutive inflammation may extend to and destroy the spinal nerves that are contiguous to the injured articulations, and thus cause permanent paralysis of the parts which they supply. (2) The consecutive inflammation may spread from the joints of the spine to the theca vertebralis, and thus induce spinal meningitis. What then is chiefly to be apprehended is, that the product of this meningeal inflammation, on being effused into the spinal arachnoid cavity, may compress the spinal cord so as to arrest its functions, and thereby cause paraplegia, or even death. (3) The consecutive inflammation may spread still further toward the centre, and attack the spinal cord itself, thereby causing spinal myelitis, and, in this manner, paralysis with a fatal result. Happily, however, there is not the same risk that an inflammation which involves the bones of the vertebral column will spread inward, and successively attack the spinal meninges and the spinal cord, as there is, in cases where the cranial bones are inflamed, that the inflammatory process will spread inward and successively attack the cerebral meninges and the cerebral substance; for, in the head, the dura mater, being firmly adherent to the cranium, performs the office of an internal periosteum, whilst, in the spine, not only does each vertebra possess a distinct periosteum, but the theca vertebralis, or spinal dura mater, is also comparatively free, being attached by a very loose connective tissue only to the walls of the spinal canal. Whilst the cranium, the cerebral meninges, and the brain itself, are formed in close connection with each other, the vertebral column, the spinal meninges, and spinal cord are formed in loose array; and, therefore, an inflammation cannot extend itself from one structure to another, through contiguity, in the latter organs, with anything like the same facility that it can in the former.

After long and wide experience, Mr. Hilton concludes: "I have generally found that almost all these diseases of the spine are the result of slight accidents overlooked."[1] It has been shown in the preceding pages, that slight falls upon the back, especially on the dorsal region thereof, and where the intervertebral substances and bodies of the vertebræ are situated in the line of extension, and the laminæ, spinous processes, etc., in that of compression, may be attended by detachment (more or less extensive) of the intervertebral substances from the vertebral bodies, and that these lesions, if overlooked or maltreated, can lead to all the evil results that have been mentioned above. The importance of continuous rest in bed, as a remedial measure, in such cases, cannot be over-estimated, and must not be forgotten.

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[1] Ibid., p. 52.

Hæmaturia from Contusions and Sprains of the Back. — Traumatic lesions of the kidneys, with bloody urine, occur so frequently in cases where severe contusions and strains, or wrenches, are sustained in the lumbar regions, that a pretty full account of them is necessary in this place.

The source of the hemorrhage, in these cases, it is seldom difficult to determine; for, when blood is found intermingled with the urine, after such injuries of the loins, it may generally be inferred with safety that one (at least) of the kidneys is also injured. When, however, slender, cylindrical, pale pieces of fibrin, or dark-colored coagula having a similar shape, are seen in the urine, the surgeon may be sure that the blood has come from the kidney, for these clots have been moulded in the ureter and then have been washed down therefrom by the urine. Moreover, when blood is passed intimately blended with the urine, but without coagula, in cases of lumbar injury, it has likewise, in all probability, a renal origin.

It will be remembered that the kidneys are two dense and rather brittle glands which lie close to the sides of the spinal column from the first to the third lumbar vertebræ inclusive, and outside of the peritoneum; that they are surrounded, and held in place with considerable firmness, by connective tissue containing much fat; that the right kidney lies rather lower than the left; and that each of them projects downward below the last rib, and, behind, is covered by the quadratus lumborum muscle. Hence, all violent flexures of the upper lumbo-vertebral articulations from sprains or wrenches are liable to be attended by corresponding bends and breaks of the kidneys; hence, also, the impact of powerful blows on the lumbar muscles may readily be transmitted through these muscles to the kidneys themselves, with enough force to contuse or even tear those organs. Finally, the renal lesion in these cases, whether consisting merely of contusion, or of slight rupture, or of extensive laceration of the renal substance, is usually attended by hæmaturia.

But, when the kidneys contain calculi, and when they are congested, as, for example, in the first stage of Bright's disease, or when their texture has become weakened, as, for instance, in chronic parenchymatous nephritis, comparatively slight injuries of the lumbar region may be attended by hæmaturia.

The clinical features or characteristics of the above-mentioned forms of renal injury can best be presented by the narration of some examples. In military life, the blow on the lumbar region which causes the mischief, may result from the explosion of a shell, as happened in the following instances, two in number, which were reported during the late civil war:—

J. H. P., Co. K, 142d Pennsylvania Vols., aged 20, was struck on the left lumbar region, July 2, 1863, at Gettysburg, by a large fragment of shell, which caused a grave contusion with ecchymosis, but without abrasion of the skin. There was shock, and much pain and tenderness at the injured part, and the urine was scanty and bloody. The pain extended along the course of the ureter, and there was retraction of the testicle with smarting at the orifice of the urethra. There was much difficulty in micturition, and occasionally tubular clots of blood were passed, after which the urine flowed in a stream, with great relief. The patient was also suffering from diarrhœa. He was treated with hot fomentations applied to the injured part, and with chalk mixture and spirit of nitric ether, until the 11th, when he had rallied sufficiently to be transferred to the Satterlee Hospital, at Philadelphia. There he was treated with infusion of buchu, together with counter-irritation applied to the loins; and, as soon as the irritability of his bowels permitted, he was placed on nourishing diet, with ferruginous medicines, and bitter tonics. The hæmaturia disappeared after the third week from the reception of the injury. The patient gradually convalesced, and, on December 31, 1863, was transferred to the Invalid Corps.[1]

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[1] Med. and Surg. History of the War of the Rebellion, Second Surgical Vol., pp. 20, 21.

This example affords a good clinical illustration of the traumatic lesion of the kidneys, by which powerful blows on, or violent contusions of, the lumbar regions, are not unfrequently accompanied. The renal symptoms were very clear. They were shock, pain in the bruised and torn kidney, which extended downward along the course of the corresponding ureter, with retraction of the testicle on the same side, and smarting at the urethral orifice. The urine was bloody, and, at times, contained also coagula which had been moulded in the ureter. At such times the act of urination was very difficult, and the difficulty lasted until the coagula had passed through the urethral canal. Their voidance was always followed by copious urination, and by a sense of great relief. The hæmaturia continued for three weeks, but the patient gradually recovered.

From the nature of the vulnerating force, from the presence of shock, from the intensity and persistency of pain in the injured kidney and its excretory duct, etc., from the long continuance of hæmaturia, and from the severity of the renal symptoms in general, it is but just to infer that the renal lesion in this case was extensive, and probably consisted of laceration as well as contusion of the renal parenchyma. Notwithstanding, the patient slowly regained his health. This point is of much practical importance; for, aside from other considerations, the happy result helps to show that rupture of the kidney is an accident from which recovery is more common than it is from a similar lesion of any other important viscus.

The next case belongs to the same category as the last:—

Lieutenant H. T. Burrows, Co. C, 7th Maryland Vols., was struck May 5, 1864, by a fragment of shell, on the left lumbar region. He was treated during one week at the second division hospital of the Fifth Corps, in the field. Severe pain and difficult micturition, with hæmaturia, led to the belief that laceration of the left kidney had resulted. On the 12th, this officer was sent to Washington, and there was treated in quarters. He recovered; and, on June 8, he was placed on court-martial duty.[1]

Besides the examples just related, there were also observed, during the late civil war, "a number of cases of recovery in which there was reason to suspect the existence of laceration of the kidney, or, at least, of severe contusion of its substance. Unfortunately, they are not reported with fulness or precision of detail."[2] Taking these cases, however, for what they are worth, they will serve to increase considerably the aggregate of instances in which traumatic lesions of the kidneys, attended with hæmaturia, and caused by lumbar contusions, have eventuated in cure; and, for this reason, I have thought it worth while to mention them.

Mr. Shaw refers to the case of a woman who had been bruised in the loins, from the falling in of the roof of her dwelling; and who, it was claimed, had sustained a renal lesion thereby.[3] Albuminuria also was present.

When great strains or wrenches of the vertebral articulations in the lumbar region are caused by alighting upon the feet in falling, the kidney may be extensively ruptured at the same time, as happened in the following instance reported by Dr. Anders:—

A well-built lad, aged 15, fell from the second floor of a house to the ground, without becoming insensible. He said that he struck the ground first with his feet, and then with his right hip. No external mark of injury, excepting a slight purplish spot over the right trochanter. No fracture of any kind, and no symptom of concussion of the brain or spinal cord. He could not walk very well, but was able to move his extremities freely when lying in bed. Pulse 60, and small; sensibility not decreased. He freely passed bloody urine. He complained of severe pain in the abdomen, especially in the left renal region, but nothing abnormal could be detected by inspection or palpation. The microscope showed the urine to contain a large number of red blood-corpuscles. Well-marked symptoms of internal hemorrhage appeared and increased; and, at 11 A. M. next day, he died in consequence of inward bleeding. During the night the urine was very little bloody. In the morning it was quite clear. *Autopsy.*—A dark-blue tumor of the size of a child's head, extending from the iliac fossa to above the tenth rib, and covering the three superior lumbar vertebræ, was found in the abdominal cavity. It consisted of coagulated blood, wherein the left kidney, which had been torn into two distinct halves, was found imbedded. The rupture was transverse, extending from the anterior superior part of the organ to the posterior inferior, through the capsule and the parenchyma. The pieces of the kidney were about two inches distant from each other, and entirely separated from their adhesions. The left ureter was torn across, and was attached, to the length of two inches, to the lower fragment; the corresponding renal vein and artery were in the same condition. The right kidney was perfectly sound. The peritoneum was not ruptured. No fluid was contained in the abdominal cavity, and no blood in the bladder.[1]

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[1] Ibid., p. 21.

[2] Ibid., p. 20.

[3] Holmes's System of Surgery, 2d edition, vol. ii. p. 363, foot-note

In this case, the left kidney, together with the accompanying ureter, renal vein, and renal artery were torn completely across, while all the other organs were unaffected; and the force which caused this immense laceration had been indirectly applied.

The *rationale* of the hæmaturia was probably as follows: The blood being still liquid, for some hours after the accident, flowed down through the severed ureter into the bladder, and this sanguinolent flow continued until the ureter itself became plugged by the formation of coagulum. Then the urine which was secreted by the right kidney remained clear, that is, unstained with blood, and in that condition was discharged in the morning before the patient died.

But, the lacerations of the kidneys which result from falling upon the feet, buttocks, or back, etc., are, for the most part, also attended with lacerations of other important viscera, as was observed in the following instance recorded by Professor Fayrer:—

The patient, a Hindoo, aged 25, fell from a tamarind tree, and fractured both arms. He was brought to the hospital, and appropriately treated; but the wounds did not do well, and he died in consequence of tetanus, sixteen days after the event. There was no indication of internal mischief beyond a complaint of pain in the epigastrium on the day after the accident, when uniformly bloody urine, without any clots, was passed. Next day, the urine was also bloody, but there was nothing more till death. *Autopsy.*—At the upper end of the left kidney was a rupture running into the hilus, where the areolar tissue was infiltrated with blood. A great part of this kidney was softened. There was some coagulated blood over the kidney and left side of the pelvis, but no peritonitis. Two ounces of blood clots lay in the great omentum. The spleen had two ruptures in its posterior edge, the upper one being very deep. The liver had a superficial rent on the posterior margin of its right lobe, and two others on the under surface. The liver was also studded with light-gray pyæmic patches, which Professor Fayrer attributed to emboli from the ruptured spleen. The heart and great vessels were found to contain coagula.[2]

In the example just presented, hæmaturia appeared on the second day, and constituted a prominent symptom. It was also the form of hæmaturia that characterizes renal injury, when no coagula are voided in the urine. It lasted, however, only two days, although it was caused by a rupture at the upper end of the left kidney, which extended into the hilus. The patient died sixteen days after the injury, of tetanus; and, at the autopsy, a great part of the torn kidney was found to be softened.

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[1] Med. News and Abstract, January, 1880, pp. 41, 42; also Brit. Med. Journal, Oct. 18, 1879.

[2] Med. Times and Gazette, May 18, 1867; also, New Sydenham Society's Biennial Retrospect, 1867–8, p. 187.

Sometimes, the liquid voided by urination, in these cases of renal injury, consists of almost pure blood, as was specially noted in the following instance:—

Private Henry Greene, Co. H, 9th Cavalry, entered hospital at 6 P. M., December 15, 1870, at Fort Quitman, Texas, having been run over by a wagon at 8 A. M., while on his way to Fort Quitman from Eagle Springs. It was thought that both wheels of one side had passed over his right hip and thorax. The patient was suffering, when admitted, from shock and extreme depression. His extremities were cold, and he was almost pulseless at the wrist. But he was perfectly conscious; the beating of his heart was feeble but regular, and 104 per minute; respiration 44. Death from shock and internal hemorrhage ensued at 7.30 A. M. of the following day, "the patient having passed, through the night, a quantity of nearly pure blood from the bladder." *Autopsy*, ten hours after death.—"A large effusion of blood into the abdominal cavity was found, and a longitudinal rupture of the right kidney, throughout nearly its entire extent. The bladder was normal and empty." The liver also was ruptured through almost the whole of its antero-posterior diameter, following the junction of the right with the left and quadrate lobes, to within an inch of its anterior margin. The sternum was fractured at the junction of its upper and middle third. The eighth rib (right), too, was fractured two inches in front of its angle.[1]

Dr. Roddick reported the following case in which pure blood was passed, and exhibited the specimen. A healthy woman, aged 60, had fallen down a long flight of stairs, and was picked up insensible. There was no wound, but on recovering consciousness she complained of great pain in the right loin; vomiting began, and, in spite of all treatment, continued to the end. The bowels became tympanitic and refused to act. Pure blood was passed from the bladder during the first twenty-four hours; subsequently, the urine was mixed with blood, and on the fourth day it was nearly clear. Rupture of the kidney was diagnosed, and ileus was suspected on account of the obstruction of the bowels and their great distension, though no tumor could be felt. Rectal injections were employed without any benefit. At the autopsy a large clot of blood was found surrounding the right kidney, which presented a laceration on the border, extending into the pelvis of the organ. The kidneys were firm and slightly granular. The bowels were distended but not obstructed; it was thought that perhaps the large blood clot might have pressed upon the ascending colon and produced the obstruction.[2]

Prognosis.—Hæmaturia from contusions and sprains, or wrenches, of the lumbar region is, in most instances, not a very dangerous symptom; for usually it disappears in the course of a few days, without leaving any trace of organic disease of the renal tissue behind. Concerning hæmaturia from this cause, Le Gros Clark says that among the many cases he has witnessed, he has never had reason to suspect that nephritis or organic disease followed in any."[3] On the same point Mr. Shaw remarks: "When such an important gland as the kidney has been crushed and broken, to such an extent that hemorrhage goes on from a rent in it for several days, it might be thought probable that the damage would be followed by ulterior bad results, especially that inflammation—nephritis—would ensue. But extensive observation negatives this view; general experience shows that when patients recover from the immediate effects of hæmaturia brought on by sprain of the spine, they are not more prone than others to renal complaints."[4] In regard to hæmaturia from sprain of the back, Mr. Bryant observes: "It is not generally a very serious symptom, unless the kidney is ruptured; as a rule, it disappears gradually, and no evidence remains that organic renal disease is ever the consequence."[1]

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[1] Circular No. 3, S. G. O., August 15, 1871.

[2] Medical News, November, 18, 1882.

[3] British Medical Journal, October 3, 1868.

[4] Loc. cit., pp. 362, 363.

Concerning the *symptoms* and *prognosis* when *rupture of the kidney* is present, Mr. Bryant also says: "When not very severe, and uncomplicated with other injuries, such cases usually do well. It [that is, rupture of the kidney] is generally known by an attack of hæmaturia and local pain following a blow on the lumbar region. The hæmaturia may be but slight and passing, or not show itself until the second day. It may cease also after the lapse of two or three days, when it is probable that only a contusion of the kidney has taken place; for, in more severe injuries, the bleeding may last fifteen days or even more. At times clots will be passed, assuming the shape of the ureter, and I have before me the notes of some half dozen cases in which these symptoms were present, and from which recovery took place. These clots, however, at times give rise to retention of urine by blocking up the urethra. Retraction of the testicle is an occasional symptom, and so is pain in the course of the ureter."[2] This paragraph sums up so clearly and so tersely the symptoms, etc., of rupture of the kidney from contusions and strains, or wrenches, of the lumbar region, as they severally presented themselves in the examples related above, that I have quoted it in full.

It should, however, be noted that in one of these examples (it was recorded by Professor Fayrer), although the hæmaturia did not appear until the second day, and lasted only two days, the autopsy revealed a rupture at the upper end of the left kidney which extended into the hilus, instead of a renal contusion; but it is probable that such a limitation of the hæmaturia is rather exceptional than otherwise, in cases where the rupture is so extensive.

In the last two of the illustrative cases presented above, the urinary discharge was observed to consist of pure or nearly pure blood. Nevertheless, the loss of blood from hæmaturia, when caused by contusions and sprains of the back, is rarely so great as, *per se*, to endanger life. Mr. Shaw, however, relates one case where there was good reason for alarm:—

> The patient was a young man. Although the sprain was not very severe, the renal hemorrhage was uninterrupted, and unusually profuse, during the first four days; it nearly ceased for two days; then it returned, and continued for two days, with its former profusion; it now ceased for one day; it appeared, however, on the next day, the tenth, in great quantity; but then it ceased permanently. The patient, meanwhile, had become blanched and excessively weak.[3]

In this case, the large quantity of blood that was discharged from the urinary organs, together with the rapid appearance of the signs of acute anæmia, clearly indicated the danger. So, likewise, in all those rather infrequent cases of hæmaturia where the prognosis is not favorable, the general symptoms will sufficiently indicate the peril. The proofs of strong shock and great depression may present themselves. If the liver or spleen be also ruptured extensively, there will, too, be unmistakable signs of internal hemorrhage. Besides, the torn viscus may exhibit considerable tenderness under pressure.

Wounds of the cortical or secretory portion of the kidney are represented to be less dangerous than wounds of the tubular or excretory portion of the gland. (Agnew.) It is probable that this proposition is also applicable to the lesions of the kidney which are caused by contusions and sprains of the back.

Treatment.—Hæmaturia, when very profuse, should be combated by administering the fluid extract of ergot, in half-drachm doses, three or four times a day, together with gallic acid, in ten-grain doses, at the same intervals. In some sthenic cases, however, it may be advisable to give, instead of these remedies, the acetate of lead, in styptic doses of two grains, every hour or two, until relief is obtained. But, generally, the employment of ergot and gallic acid should be preferred.

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[1] Practice of Surgery, p. 205, Am. ed. 1879.

[2] Ibid., p. 432.

[3] Loc. cit., p. 362.

Pain in the injured kidney and ureter, etc., is to be combated with opium or morphia; but, at the same time, these narcotics must be exhibited with caution. Rest in bed should be enjoined, together with a milk diet. When coagula form in the bladder, and cannot be spontaneously passed by the urethra, causing retention of urine, they should be broken down by injecting warm water through a large-sized catheter.

The *medico-legal* relations of hæmaturia from contusions and sprains of the back still remain to be considered. Mr. Shaw relates the case of a gentleman who claimed in a law court compensation from a railway company, for Bright's disease resulting from injuries received in a railway collision. The injuries consisted of a bruise over the right ilium and side of the loins. On the following day he observed blood mixed with his urine; and, for four days, he continued to pass blood. At this time his urine was found to contain albumen, and it continued to be albuminous from the date of the accident to that of the trial, a period of eleven months. The medical witnesses for the plaintiff held that the albuminuria, that is, the parenchymatous nephritis, had been caused by the injury of the right kidney that was inflicted in the collision. The medical witnesses for the defence (Mr. Shaw was one of them) "expressed a strong opinion that the plaintiff was suffering from the disease when he met with the accident, and that the injury could not have brought it on."[1] But, to say "that the injury could not have brought the disease on," in this case, is tantamount to asserting that a traumatic lesion of the kidney, which manifests itself by hæmaturia appearing on the day following the accident and continuing for four days, cannot give rise to a structural disease of the kidney of an inflammatory character. Such an assertion cannot reasonably be maintained; for Professor Fayrer, in the case of the Hindoo, related above, who had hæmaturia beginning on the day following the accident, and lasting only two days, and who died in consequence of tetanus sixteen days after the injury, found at the autopsy that there was a rupture of the left kidney extending into the hilus, and that a great part of this kidney was softened, that is, had become the seat of a structural disease, and had undergone a structural change, such as is not unfrequently produced by the inflammatory process; or, in other words, that the rupture of the kidney had been attended by traumatic nephritis. There is, therefore, no reason for doubting that, in at least occasional instances, the injury of the kidney which causes hæmaturia, gives rise also to Bright's disease. In the case just mentioned, the jury, notwithstanding the medical testimony adduced by the defence, "awarded heavy damages to the sufferer," and it may well be that the verdict was a righteous one.

A legitimate inference from the foregoing, which has value for medico-legal uses, is, that although some surgeons of large experience have never seen a case in which hæmaturia from contusions and sprains of the back was followed by nephritis or by organic disease of the kidney, nevertheless, such cases do sometimes occur; and that, whenever they do occur, their existence ought to be recognized. It is also pretty certain that Bright's disease does not often arise from renal traumatism; but, precisely how often, future experience alone can determine.

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[1] Loc. cit., p. 363.

HEMORRHAGE INTO THE VERTEBRAL CANAL FROM SPRAINS, VIOLENT FLEXURES, AND TWISTS, OR WRENCHES, OF THE BACK.—This accident has no surgical importance, unless paraplegia more or less complete ensues. In the cases where it occurs, the chief proximate cause of disability and danger to life is the compression of the spinal cord, or of the spinal nerves before they issue from the intervertebral foramina, which the extravasated blood occasions. As in the cranium, so also in the vertebral column, the extravasated blood which compresses the nerve-tissue may be effused between the dura mater and the bone, that is, externally to the dura mater, on the one hand; or internally to that membrane, that is, between it and the nerve-structures, on the other. We are, therefore, liable to meet with both extra-dural and intra-dural hemorrhages, of a perilous character, in the vertebral canal as well as in the cranial cavity.

It has already been stated, in this article, that the ligamenta subflava are in direct relation with the *meningo-rachidian veins*, and that laceration or violent stretching of those ligaments would pretty certainly be attended by rupture of these veins; also, that the posterior common ligament is in relation, by its anterior surface, with the *venæ basum vertebrarum*, and by its posterior surface, with the dura mater of the spinal cord, from which it is separated only by the *plexus venosi spinales interni* or longitudinal spinal sinuses, with some loose connective tissue containing fat, and that laceration of this ligament would be likely to be attended by rupture of these venous plexuses or sinuses, and, possibly, by rupture likewise of the dura mater of the spinal cord. Moreover, the laceration or violent stretching of these ligaments is liable to be attended by rupture of the arteries which, on entering the vertebral canal, come into relation with these ligaments as well as with the intervertebral disks, namely, the *rami spinales.* The arteries which may be ruptured are numerous, the veins are not provided with any valves which could prevent regurgitant hemorrhage, and the dura mater is attached but very loosely to the inner surface of the vertebral canal. Thus, it appears, that when the vertebral ligaments are much torn by sprains, violent flexures, and twists, or wrenches of the vertebral column, there are many bloodvessels from which hemorrhage may occur if these vessels also be torn open, and that ample means are afforded by looseness of the connective tissue for the extravasated blood to accumulate, in great masses, between the dura mater of the spinal cord and the bone, as well as within the hollow cylinder or sheath which is formed by the dura mater itself.

When, in such cases, the hemorrhage soon ceases, and the quantity of the extravasation is not large, it is probable that recovery will ensue; for the effused blood will be more or less completely absorbed, and thus the spinal cord will be more or less completely freed from compression. But, when the hemorrhage continues unchecked, the paraplegia arising therefrom will increase, and it will gradually spread upward until the superior extremities, too, become paralyzed; and finally, the functions of the phrenic nerves will likewise be suspended, the diaphragm will no longer contract, the respiratory movements will entirely cease, and then death will of course immediately result, as happened in the following example which occurred in the practice of Dr. John J. Crane, of New York, and in which I assisted at the autopsy:—

Mr. S., an actor, aged about 50, sustained a violent injury in the root of his neck, shoulders, and back, from being thrown thereon while wrestling, on a Sunday afternoon. Being unable to arise without assistance, he was picked up and laid upon a bench by those around. Afterward he was put into a coach; and, being held in a semi-recumbent position, he was carried to his home. Dr. Crane saw him, for the first time, about nine o'clock P. M. He was then unable to move his lower extremities, and exhibited all the symptoms of paralysis from spinal injury, so far as they were concerned. His urine, however, was passed voluntarily, the bladder and abdominal muscles being unaffected. The upper extremities, also, were not paralyzed.

On the following morning (Monday) it was found that the paralysis had reached a higher point, that there was retention of urine, and that catheterization was necessary. Afterward, the paraplegia continued steadily to advance, travelling up the trunk, involving the upper extremities, involving likewise all the respiratory muscles excepting the diaphragm, and, finally, attacking the origin of the phrenic nerves, when he immediately ceased to breathe. He died on Wednesday night, somewhat more than three days after the accident. His bowels were moved only once, and then by enema, on Tuesday morning. He complained of pain only in the lower part of the neck, and exhibited signs of severe suffering whenever his head was moved. There was tenderness under pressure, and considerable swelling in the lower and back part of the cervical region. But no displacement or irregularity of the spinous processes, nor of any other parts of the vertebræ, could be detected. His mind was clear to the end.

The *autopsy* revealed a very extensive effusion of blood within the theca vertebralis, which distended that membrane and compressed the spinal cord throughout almost the whole of its extent, namely, from the cauda equina up to the superior cervical region. The spinal cord itself was not wounded. The theca vertebralis was ruptured to the extent of about one-third of its circumference, in the lower part of the cervical region. The ligaments connecting the fifth, sixth, and seventh cervical vertebræ exhibited much laceration. A fissured fracture also passed longitudinally through the fifth, sixth, and seventh cervical vertebræ. There was not much displacement of bone, certainly not enough to press on the spinal cord in any way, and not enough to be cognizable by external examination. The blood found within the theca vertebralis was, for the most part, extravasated from the vessels of the cord—that is, from the arteriæ spinales, anterior and posterior; but, no doubt, some blood from without had entered the cavity of the theca vertebralis through the ruptured aperture in that membrane. It was, however, evident that the paraplegia had slowly crept upward in this man's body, just as the effused blood accumulated in the thecal cavity, commencing in the lower end thereof; and, that death had resulted from compression of the spinal cord, arising from this cause.

In the very instructive case which has just been related, there was a longitudinal fissuring of the last three cervical vertebræ, as well as such a laceration of the ligamentous tissue and neighboring bloodvessels as is often found in cases of sprains, from contusions and violent flexures of the vertebral column. Still, the case practically belongs to the same category as sprains and wrenches of the vertebral column, because several vertebral articulations did, in fact, sustain the lesions which characterize this form of injury, and examination during life did not and could not reveal any lesion of the vertebral column, excepting the sprains of the vertebral joints. Moreover, if in this case there had been no intra-thecal hemorrhage, and no compression of the spinal cord, or had the effusion of blood been moderate, and had it been followed by absorption, the patient's recovery might easily have ensued; and had his recovery so ensued, the fissures in the last three cervical vertebræ would never have been discovered, and the injury would have been considered as merely a sprain or wrench of the back. But, at all events, this example illustrates in an excellent manner the clinical history, that is, the symptoms which are likely to present themselves, in fatal cases of compression of the spinal cord from the extravasation of blood within the spinal dura mater, where life is prolonged for three or four days.

To illustrate compression of the spinal cord from hemorrhages which occur externally to the spinal dura mater, Mr. Shaw relates at much length the case of a woman, aged 60, admitted to the Middlesex Hospital under his care, in March, 1841, having been injured in the back by falling down a flight of steps shortly before:—

No irregularity in the line of the spine could be perceived; and, although she sat up for examination, there was no particular part of the back which seemed to be particularly weak. Both upper extremities and the right lower extremity were deprived of voluntary motion; but sensation was nearly perfect, for she spoke only of a little numbness in them. Reflex movements could not be excited in the paralyzed upper extremities, while they were particularly lively in the paralyzed lower extremity. The breathing was not disturbed. There was at first retention of urine; and, for a few days, incontinence; but soon afterward she regained the natural control over urination. The bowels acted regularly. During the first ten days no perceptible change took place; but in the following fortnight a slow and gradual increase of power over the paralyzed limbs was observed; after that, however, all progress seemed to cease. She was retained in the hospital for three months; but her subsequent history is not known. "That in this case," says Mr. Shaw, "the blood which escaped had been poured into the loose space intervening between the osseous walls of the canal and the theca spinalis seems most probable; and, also, that the source of the blood was the venous sinuses which line the interior of the canal in the form of plexuses." He further says: "As the paralysis was partial, three alone out of the four extremities being affected, and motor power being the only property lost, it may be inferred that, if blood extravasated external to the theca were the compressing agent, it had been collected in the canal in unequal quantities at different parts. Such an hypothesis would explain how one of the lower extremities escaped being deprived of its motor power."[1]

But, inasmuch as there was no autopsy in this case, the conclusion that intra-vertebral hemorrhage had occurred externally to the theca vertebralis must be held to be unproved, and as at least to that extent uncertain.

Dr. Deville, in 1843, in examining the body of a man who had died in consequence of falling from a great height on to the pavement, found, on laying upon the spinal canal, a most extensive extravasation of blood, completely filling up this canal in its whole length, and extending upward, even beyond the point where the spinal cord had been cut across, when the brain was taken out. No trace of injury whatever was detected in the cranial contents. This man, when admitted to hospital, was collapsed and perfectly insensible. There was no paralysis, nor muscular spasm. In this state he lay for some hours, and then died. Except the intra-vertebral hemorrhage, no cause of death could be found.[2]

Mr. Le Gros Clark mentions a remarkable case of the same kind, which was narrated to him, but which he did not see:—

A man was violently struck on the back by a chain-cable; there were no immediate symptoms of spinal injury, but a paraplegic condition soon supervened, extending rapidly upward and destroying life by asphyxia. The theca was found distended with fluid blood, derived from a ruptured spinal artery. He likewise mentions another case: A man was injured in a collision in the tunnel, four or five miles from Brighton. He walked this distance with some difficulty into the town; and, within twenty-four hours, became entirely paraplegic. He slowly recovered, so that, at the end of two years, he was able to walk as well as before the injury. One spot on the back was always tender; and, at times, still continued so.[3]

The close resemblance which the symptoms that presented themselves in this case, bore to those that were observed in the preceding case, indicates that the pathological lesion was the same in both instances, namely, extravasation of blood within the spinal dura mater from ruptured spinal arteries, whereby the spinal cord was compressed.

The *symptoms* which result most frequently from this lesion are those of paraplegia, coming on some little time after a violent contusion or sprain of the back, the paralysis appearing first in the legs, and extending upward with more or less rapidity, according to the nature of the case. At all events, these are the phenomena which were observed in both of the instances mentioned by Le Gros Clark, as well as in that which I have myself recorded.

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[1] Loc. cit., pp. 364–366.

[2] Mém. de la Soc. de Chirurg. de Paris, t. iii. p. 180; also Holmes's System of Surgery, 2d ed., vol. ii. p. 300.

[3] British Medical Journal, October 3, 1868.

Treatment.—Should the surgeon be able to make a differential diagnosis in a case where this accident has occurred, it may be advisable for him to prescribe the fluid extract of ergot in doses of thirty drops every four hours, or the acetate of lead in doses of two grains every hour or two, with a view to suppress the bleeding. In cases where the hemorrhage has ceased, it will generally be advisable to administer potassium iodide in doses of ten grains every eight hours in simple syrup, with a view to promote absorption of the effused blood. Quiet should be enjoined, and measures should be employed to prevent the occurrence of spinal meningitis and myelitis.

II. INJURIES OF THE VERTEBRAL COLUMN.

Dislocations of the Vertebræ.

The traumatic lesions to which the several pieces of the spinal column are exposed consist, (1) of *pure dislocation*, (2) of *pure fracture*, and (3) of *dislocation combined with fracture*. Experience has shown that, leaving gunshot wounds of the vertebræ out of the account, pure dislocation occurs quite as frequently as pure fracture, and that dislocation combined with fracture is met with much oftener than either of them; and, perhaps, almost as frequently as both conjoined. For instance, Professor Porta found in 27 cases, *pure* dislocation in 7, dislocation complicated with fracture in 14, with 6 recoveries, so that there could not, by any possibility, have been more than 6 examples of *pure* fracture. Dissection was practised in 20 of the 21 fatal cases, that is, in all but one. The fracture complicating the dislocation was often so slight as not to be distinguishable until the autopsy revealed it. Again, Mr. Bryant found in 17 cases where the nature of the injury was verified by post-mortem examination at Guy's Hospital, during a period of five years while he was officiating as surgical registrar, that 6 were instances of pure dislocation, 3 of pure fracture, and 8 were examples of dislocation and fracture combined.

Clear views on this subject are of practical importance, because pure dislocations of the spinal column are, as a rule, more amenable to treatment than corresponding fractures with a like degree of displacement. In the latter cases, the spinal cord is apt to be scratched and torn by the sharp points and edges of the fracture-splinters and fragments, in addition to being compressed by the displacement of bone. The late Dr. D. S. Conant, of New York, reported a case of fracture of the twelfth dorsal and first lumbar vertebræ,[1] in which the patient lived six days, the spinal cord being divided by a splinter from the first lumbar vertebra, and not by displacement of the vertebra itself. It might well be that an apparently hopeless case of spinal dislocation could be saved by reducing the luxation, while a case of fracture involving the same part, with a similar amount of displacement of bone and paralysis of body, would not be saved by a like proceeding; and that, too, because of the injury inflicted upon the cord by the splinters and fragments of broken bone. Moreover, in certain cases of *cervical* dislocation where the reduction proves to be difficult, although it is indispensable in order to save the patient from speedy death, the surgeon will be more likely to persevere until he accomplishes the reduction and thus frees the spinal cord from injurious compression, if his mind be clear in respect to the diagnosis, than he will if his opinion be unsettled. Many cases of this sort have already been recorded, some of which have been saved by a timely reduction of the dislocation, while others have perished from the lack of this proceeding; and more cases of the same sort will hereafter be met with. The clearness of view and accuracy of diagnosis needful for their proper treatment, are much more likely to be attained by making a separate study of vertebral dislocations, than by considering them together with vertebral fractures—that is, than by discussing the traumatic lesions of the vertebræ, *en masse*, as practised by most writers and lecturers on surgery, at the present day, in England and America—and, therefore, I shall not follow their example.

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[1] American Medical Times, 1861, pp. 359, 360.

Until a recent date, *pure* dislocations of the vertebræ were held, by even the best informed surgeons, to be of very rare occurrence; and some of equal eminence positively denied that dislocation of the body of a vertebra, unattended with fracture, ever occurred at all. Among the latter, Delpech was specially prominent. Abernethy likewise taught: "There can be no dislocation (of the vertebræ) surgically speaking—we do not take the word in its etymological sense; in surgical language, a dislocation is a displacement of bone, with a laceration of ligament unaccompanied with fracture; for if there be a fracture, it is not a dislocation; but, from their position, if one vertebra be knocked in, its articular surfaces must be broken" (South). Sir A. Cooper declared that he had never seen a pure dislocation of one vertebra upon another; but, at the same time, he admitted the possibility of its occurrence when he said: "If luxation of the spine ever does happen, it is an injury which is extremely rare." In England, Mr. Lawrence was the first to demonstrate that vertebral dislocation, unattended by fracture, in reality did occur. He reported the following example:—

A robust porter, aged 22, while "carrying a heavy barrel on the back of his head and neck, slipped on descending some steps, and fell on the buttocks, the burden resting on the head and upper part of the neck. He was immediately deprived of sensibility in the trunk and limbs, and of all power over the voluntary muscles of these parts. When brought to the hospital he was completely insensible, and incapable of voluntary motion below the neck." The respiratory movements were performed apparently by the diaphragm alone. Priapism was noted. On the next day "there was pain in the lower part of the neck; he could move the arms very slightly, and had a little feeling in the front and upper part of the chest." On the third day "he experienced a tingling sensation in the hands, and was sensible to impressions on the upper part of the arms and thighs." On the morning of the fifth day, very early, he died from asphyxia and exhaustion.

Autopsy.—"No displacement or inequality could be discovered by external examination, when the body was laid on the face. After cutting away the muscles from the back of the spine, the cartilaginous surfaces of the superior articular processes of the fifth cervical vertebra came into view. They were exposed in consequence of the inferior processes of the fourth vertebra having been completely dislocated forwards, and remaining fixed in their unnatural position. The yellow ligaments connecting the laminæ of the two vertebræ [ligamenta subflava] were torn through, and the bifid apex of the fourth spinous process lay in close contact with the basis of the fifth. On the front of the column an unusual projection was observed, but the anterior longitudinal ligamentous expansion [anterior common ligament] was entire. The body of the fourth was completely detached from that of the fifth vertebra, the connecting fibro-cartilage being torn through, and the body of the former projecting by its whole depth in front of the latter. In consequence of this displacement, the antero-posterior diameter of the vertebral canal was lessened about one-third."[1]

The specimen was preserved, I believe, in the museum of St. Bartholomew's Hospital. In this case, then, there undoubtedly occurred "a displacement of bone with a laceration of ligament unaccompanied with fracture;" or, in other words, there was unquestionably a pure dislocation of the fourth cervical vertebra forward upon the fifth.

The French surgeons had already ascertained that the atlas might be luxated on the axis without fracture; and that, occasionally, a luxation of the articular process on one side (unilateral dislocation) occurred among the last five cervical vertebræ.[2] But these lesions were held to be of extremely rare occurrence; and, as to luxation of the bodies of the vertebræ without fracture, the possibility of such an accident was scarcely admitted. On the latter point, Boyer says: "If we examine the facts upon which a belief of the possibility of their being luxated is founded, we shall find that the posterior laminæ of the vertebræ are uniformly broken, often crushed, and reduced to splinters, and that, almost always, when the body of a vertebra is luxated, the separation of its ligaments tears off a piece of the bone itself."[3] Boyer has been blindly followed by most writers on spinal injuries since his day. (Ashhurst.)

In 1865, however, Professor Porta's memoir on "Dislocations of the Vertebræ" was read before the Royal Lombard Institution of Science and Letters, and was summarized in Omodei's Annali Universali di Medicina, whereby the chief points made in it have become widely known. This memoir is founded on 27 cases—13 in the cervical, 10 in the dorsal, and 4 in the lumbar region. No case of luxation of the occiput on the atlas, nor of the atlas on the axis is included. There were only six recoveries. Necroscopy was practised in 20 out of the 21 fatal cases. Prof. Porta asserts that dislocations of the bodies of the vertebræ, which all authors (including Morgagni) have believed to be rare, are common enough, and met with every year in hospital practice. Experiments on the spinal column removed from the body, and denuded of its muscles, show that by vigorous torsion the intervertebral cartilage and ligaments can always be torn, and this dislocation be thus produced. He combats the opinion of Boyer that the dislocation is always accompanied by fracture, and mentions seven cases in which there was no such complication. Even when fracture does accompany the luxation, the complexion of the accident is determined by the luxation and the extent of its displacement. As already stated, 14 cases were complicated with fracture—5 in the cervical, 6 in the dorsal, and 3 in the lumbar region. He regards the concomitant fracture as a phenomenon secondary to the dislocation.[4]

In 1867, Mr. Bryant published some statistics of spinal injuries,[5] in order to show that *pure dislocation* of the vertebræ was less rare than was usually taught. During a period of five years, ending in 1858, while he officiated as surgical registrar at Guy's Hospital, 46 cases of spinal injury were admitted; and, among the 46 cases, there were 24 examples of dislocation, or of fracture, or of both combined. In 10 of them, the dislocation, or the fracture, was in the cervical region; in 14, the injury was in the dorsal region. Moreover, the nature of the lesion was verified by a post-mortem examination, in 17 instances. Of these, 6 were *pure dislocations*, 3 were *pure fractures*, and 8 were examples of *dislocation combined with fracture*, as already stated. Of the *pure disloca-*

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[1] Medico-Chirurg. Trans., vol. xiii. part 2, pp. 394–397. 1827.

[2] Boyer's Surgery, translated by Stevens, vol. ii. pp. 230–234. New York, 1816.

[3] Ibid., p. 235.

[4] New Syd. Soc. Retrospect, 1865–1866, pp. 281–283.

[5] Lancet, April 6.

tions, 5 occurred in the cervical and 1 in the dorsal region. The nature of the lesion was verified by a post-mortem examination in every one of the 10 cases in which a cervical vertebra was injured; and thus, pure dislocation was found, beyond question, in one-half, or 50 per cent., of the cervical cases. It was found in 2 between the fourth and fifth vertebræ of the neck; in 2 between the fifth and sixth; and in 1 between the last cervical and first dorsal vertebræ. In each of the other 5 cases of injury to the cervical portion of the spine, the lesion consisted of dislocation and fracture combined. All of the examples of *pure fracture* were found in the dorsal region. Three examples of dislocation combined with fracture were also found in this region. The instance of *pure dislocation* in the dorsal region, above mentioned, occurred between the eleventh and twelfth vertebræ. The ligaments normally connecting these vertebræ were ruptured at all the joints between them, and the body of the eleventh was thrown forward. In the remaining 7 cases of injury to the dorsal portion of the spine, there was no autopsy; but the lesions occurred about the tenth, eleventh, and twelfth vertebræ.

Professor Porta's memoir and Mr. Bryant's article mark the commencement of a new epoch in the surgical history of vertebral injuries. Some forty years before, Mr. Lawrence had demonstrated, as already mentioned, that the body of a vertebra, as well as an articular process, could be disjointed from its fellow without being attended by any fracture. They, however, went much further, and demonstrated that pure dislocations of the vertebræ were not, by any means, extremely rare lesions; that, on the contrary, they occurred about as frequently as pure fractures of the vertebræ in civil practice, and that dislocations combined with fractures were met with in the spinal column at large much oftener than either of these lesions. Mr. Bryant went further still, and showed that pure dislocations were mostly found in the cervical region, but seldom in the dorsal and lumbar regions.

In 1867, awakened interest in this neglected branch of surgery was also manifested in America, by the publication of Professor Ashhurst's instructive essay on Injuries of the Spine, with an analysis of 394 cases, the clinical histories of which he had examined. His investigations, after making due allowance for all possible errors, strongly confirm Mr. Bryant's conclusions on the last-named point. Of these 394 cases of spinal injury, 124 are reported as *pure dislocations;* 104 of them being in the cervical region, 17 in the dorsal, and only 3 in the lumbar region. Now, admitting that in some of these cases reported as pure dislocations of the vertebræ, there must also have been lesions of bone, perhaps quite limited in extent, but still constituting fractures of the vertebræ with which the dislocations were complicated, the relative proportions would not be destroyed, nor even essentially changed (it is probable), for an error of this sort is not likely to occur in a greater percentage of cases in one of the spinal regions than in another. But enough has been said to indicate that, since the days of Delpech and Abernethy, of Baron Boyer and Sir Astley Cooper, great additions have been made to the stock of our knowledge concerning this important class of spinal injuries.

Here it may be well to say that, when a vertebra is dislocated, the vertebra itself, together with the part of the spinal column resting on it, is usually moved forward upon the next vertebra below it and the rest of the column. That the displacement in vertebral dislocations is generally anterior, results from the fact that the forces causing them generally act from behind, and, having ruptured the column, they drive the upper part of it forward, in which direction this part is also drawn by its own weight and by muscular action, while the lower part remains unmoved. This, Professor Porta verified in 17 out of 26 cases, and anterior displacement was doubtless present in other instances. Hence *the upper* is usually considered to be the portion of the spinal column that is dislocated. I shall endeavor to note any exceptions to this rule in regard to the displacement in spinal dislocations as they present themselves in the following pages.

It may likewise be well to say here that in all *pure dislocations* of the vertebræ, certainly in all of them that are bilateral or symmetrical, the intervertebral substance is torn completely through; if it were otherwise, the body of the upper vertebra could not be displaced forward nor backward, nor in any other direction upon the body of the lower vertebra.

Also, in dislocations of the cervical vertebræ complicated with fracture, the intervertebral substance is generally torn completely through, and the fracture is usually found in the spinous process, or laminæ, or pedicles of the dislocated vertebra itself, but not in the body. In five successive examples of dislocation and fracture combined, Mr. Bryant found in each that the body of a vertebra was dislocated forward upon the one below; that the articular processes were displaced, or separated from each other, at their joints; and that in each there was a fracture through the spinous process or laminæ of the *upper* or dislocated vertebra, the luxations having taken place at the under surfaces of the third, fourth, fifth, sixth, and seventh cervical vertebræ, respectively.[1]

Dislocations in the Cervical Region.—The ginglymoid articulation between the occipital bone and the atlas, which joins the cranium to the vertebral column, and is therefore called the *articulatio capitis*, is remarkably stable and difficult to unhinge by reason (1) of the cup-shaped depressions in the transverse processes of the atlas which receive the condyles of the occipital bone; (2) by reason of the seven ligaments, some of which are very strong, that bind the atlas to the occipital bone, and (3) by reason of the narrow limits to which the motions of the joint itself are restricted. Hence, Boyer declares that there is no example of a displacement of the articular surfaces of the occiput with the vertebral column, in consequence of external violence. Even the large carnivorous animals, which prey upon the smaller, and which have occasion to make very violent movements of the head, furnish no example of this kind. In falls upon the head, in which the neck is strongly flexed, although several cervical vertebræ may be broken, the occipital bone is never luxated upon the atlas. In the bodies of persons who have died by hanging, the atlas is often found luxated upon the axis, but the occiput is never found luxated upon the atlas. Nevertheless, dislocation of the occipital bone from the atlas has been described; it is, however, extremely rare. For instance: (1) Lassus observed[2] the case of a man, injured by a mass of hay falling on the back of his neck, who was stunned and paralyzed, and had convulsions of the upper extremities. He lived six hours. Dislocation of the occiput from the atlas, and rupture of the vertebral artery and vein were found. (Ashhurst.) (2) Paletta described[3] the case of a peasant man, aged forty, who fell head-foremost from a tree, and was paralyzed. He lived five days. Fracture of the fourth cervical vertebra and dislocation of the occiput from the atlas were found. (Ashhurst.) (3) Bouisson mentions[4] the case of a boy, aged sixteen, who was crushed under a cart, and taken out dead. Dislocation forward of the atlas on the occiput was found. The medulla was compressed, but not crushed. (Ashhurst.) (4) A case in which dislocation of the occipital bone from the atlas and axis occurred, is noted in St. Bartholomew's Hospital Reports, vol. x. p. 313. (5) Dariste is credited[5] with a case of incomplete luxation of the occiput on the atlas; cause not stated. The patient was relieved, and lived more than one year. Death resulted from other causes—tubercle of the brain. (Ashhurst.) Dariste exhibited the specimen to the Anatomical Society of Paris.

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[1] New Syd. Soc. Retrospect, 1867–68, pp. 275, 276.

[2] Pathologie Chirurgicale, t. ii.

[3] Exercitationes Pathologicæ.

[4] Revue Médico-Chirurg. de Paris, t. ii.

[5] American Journal of the Medical Sciences, O. S., vol. xxiii.

Dislocation between Occiput and Atlas—In respect to the *direction of the displacement* in dislocations at the summit of the spinal column, involving the articulation with the head, it seems that the occipital bone may be displaced backward, as well as forward, upon the atlas, for in Bouisson's case it is stated that the atlas was found dislocated forward on the occiput—that is, the occipital bone was, in reality, found to be dislocated backward on the atlas and the whole spinal column.

In regard to the *consequences* of this dislocation, whatever be its direction, it is worthy of remark that, while Bouisson's subject died immediately, Lassus's patient lived six hours, Paletta's five days, and Dariste's more than a year, death in the end resulting from another lesion. But, it is well known that any injury of the spinal cord above the origin of the phrenic nerves, that is, above the third cervical vertebra, which arrests the functions of the cord—for instance, severe compression or crushing of the cord—always causes instant death. This result, however, was noted in only one case. It is therefore evident that the degree of compression of the cord, or the amount of the displacement of the luxated bones which caused the compression, was materially less in the other cases, and very much less in two of them. This circumstance directs our attention to the fact that the foramen spinale is much wider in the atlas than it is in the other vertebræ; that the foramen magnum of the occipital bone is almost equal to it in extent; and that, therefore, a good deal of displacement of the bones may occur in disjointings at the articulation of the head, without causing much compression of the spinal cord.

In regard to the *etiology* of the luxations which are met with at the occipito-atloid articulation, an inspection of the above-mentioned examples indicates that the application of great force, in such a way as to bend the head on the atlas far forward or backward, is requisite for their causation. This force may be directly applied, for instance, by means of a crushing weight striking on the neck, and, perhaps on the head also, as was noted in the observations of Lassus and Bouisson; or it may be indirectly applied through the cranium—for example, by falling head-foremost from a great height and striking thereon, as happened in Paletta's case. But a dislocation of the occipital bone from the atlas has never been caused, as far as known, by stretching the head and neck, however great the extending force may have been, although the experiment has often been made in executing the death-sentence on criminals by hanging. Even in those cases in which the head has been torn completely off from the trunk, from laceration of the neck by the rope, the vertebral ligaments, it is believed, have always given way at some point other than the occipito-atloid articulation—at some point where the ligaments are less able to withstand the stretching.

Spontaneous luxation, however, may occur at the occipito-atloid articulation, in consequence of the destruction or extreme weakening of its ligaments by disease. Boyer mentions an example which he had seen at La Charité, and refers to a case related by Daubenton, the specimen from which was placed in the king's cabinet. Sandifort has described five specimens, found in the museum at Leyden. Mr. Hilton has presented a very instructive case of the same sort, illustrated with two wood-cuts.[1] In these cases, the ligaments connecting the first vertebra to the occipital bone must have been destroyed by ulceration; or, at least, must have become so much softened as to have quite lost their consistence and strength.

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[1] Op. cit., pp. 56–58.

Dislocation of the atlas upon the axis very often occurs. The neck is disjointed at the atlo-axoid articulation more frequently than it is at the juncture of any two cervical vertebræ beside them. The considerable variety and wide extent of the movements of the head and neck, which are executed at the triple articulation between the atlas and axis, and the peculiarities in the anatomical structure thereof which enable these different movements, particularly the rotatory ones, to be performed, much increase the chances for dislocation to occur at this compound vertebral joint, notwithstanding the remarkable strength of the apparatus itself. Moreover, in almost every instance where sudden death is caused by the luxation of a cervical vertebra, the displacement of bone which crushes or fatally compresses the spinal cord is found within the spinal foramen of the atlas or axis. But, generally, in such cases, it is found within the spinal foramen of the former, and there the act of crushing or strongly compressing the spinal cord is effected by the odontoid process of the latter.

Dislocation of the first upon the second vertebra is always forward, and may be, or may not be, complicated with fracture; but, even when complicated with fracture, the dislocation is usually the more important lesion, inasmuch as it generally is the bone displaced by the dislocation, which presses the cord from behind against the odontoid process in front, and thus places life in sudden peril. The special consideration, however, of fracture as a complication in such cases is, for the moment, deferred.

Dislocation of the atlas upon the axis, without fracture, that is, *pure* dislocation of the first upon the second vertebra, also not unfrequently occurs. It appears with probably about the same frequency as dislocation combined with fracture of the same bone. In the first variety of pure dislocation occurring at the atlo-axoid articulation, that is to be noticed in this place, the atlas is thrust or displaced forward because the transverse, accessory, and lateral ligaments have all been simultaneously ruptured by external violence, and nothing remains to hold the odontoid process in contact with the articular fossa, intended for its reception, on the anterior arch of the atlas. To produce this variety of dislocation the expenditure of great force is obviously required. The following example will materially aid in illustrating this accident:—

Lieut. J. Alman, Troop I, 4th Cavalry, was killed, March 17, 1868, in a collision between a row-boat, which was carrying him to Jefferson, Texas, and a steamboat. He was struck by the paddles of the wheel and carried under. His body was once thrown to the surface by the eddies of the water, and then sank. Every effort was made to secure his remains, but without avail, until the sixth day after the disaster, when the body, in a very advanced stage of decomposition, rose to the surface. An *autopsy* revealed a dislocation of the atlas upon the second cervical vertebra, with rupture of the transverse ligaments, and the odontoid process impinging upon the spinal marrow.[1]

In this case, the strength of the odontoid process was greater than that of the transverse and other ligaments combined. Hence, when the triple articulation to which they belonged was subjected to a great strain, they gave way and allowed dislocation forward of the atlas to occur, with crushing of the spinal cord against the odontoid process of the axis. The strength which the odontoid process manifested in this case does not appear to have been exceptional; for Dr. Stephen Smith, after making numerous experiments that bear on this point, comes to the following conclusions: (1) In a healthy condition of parts, the odontoid process has greater strength than either the anterior arch of the atlas, or the transverse ligament. (2) The odontoid process is less liable to be fractured by external violence than the body of the axis at the insertion of the process. (3) The odontoid process is not fractured by being driven against the transverse ligament or anterior arch of the atlas.[1]

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[1] Circular No. 3, S. G. O., August 17, 1871.

Again, it appears that the ligaments of the atlo-axoid articulation may be broken in detail, as it were, or one after another, by violently turning or rotating the head to one side, and that dislocation forward of the atlas may in this way be produced. In a violent rotation of the head to one side, the alar or check ligaments of the odontoid process are put upon a stretch, and twisted around this process. The momentum of the head is opposed by these ligaments alone, and, if at this time the head be inclined to either side, one of the alar or check ligaments, more tense than the other, yields first, and thus renders the rupture of both more easy. When the alar, check, or odontoid ligaments are once broken, rupture of the transverse and other ligaments easily follows. It is not improbable that the dislocation in the following instance was produced in this manner by a powerful blow in the face:—

A man, named Carter, was killed in a brawl, on the night of July 18, 1882. The blow was planted fairly in his face by his assailant's fist. He dropped to the ground as if felled by an axe, and did not move afterward. An *autopsy* showed that death had resulted immediately from dislocation of the spinal column, and injury of the spinal cord, at the junction of the atlas and axis, the lesion being identical with that caused by hanging.[2]

Such a blow, planted on the man's cheek while his head was already turned in the opposite direction, might, by rotating his head with great force still further in the same direction, readily break the odontoid or check ligaments first, and then the transverse and the other ligaments successively. Owing to the skull being articulated at its base, near the middle, on the summit of the cervical portion of the vertebral column, imaginary lines drawn from the point of junction to the farthest convexities on the skull's periphery, will represent levers, which will act on the axis of motion in the cervical vertebræ, with power commensurate to their different lengths. (Shaw.) In the case just mentioned, the portion of the head intervening between the malar prominence of the cheek and the occipito-atloid articulation would constitute a lever, through which the blow on the cheek would act with greatly augmented force upon the axis of motion in the cervical vertebræ; and, in this way, the odontoid and the other ligaments belonging to the atlo-axoid articulation would be successively ruptured, and the atlas would be dislocated upon the axis, as it were, by powerfully twisting the neck by means of force applied to the face.

So, too, Louis, the famous French surgeon, in endeavoring to distinguish, among those who had died by hanging, the suicide from the victim of assassination, found that those who were merely suspended by a rope died simply from strangulation, while those who, after being swung off from the gallows, had their necks *twisted*, had also the first cervical vertebra luxated upon the second. Moreover, the hangman at Lyons having reduced the practice of his infamous profession to its elemental principles, always produced disjointing of the neck by sitting on the shoulders of the culprit, and rotating the head and bending it to one side until he heard the crack which informed him that he had effected dislocation of the atlas upon the axis. (Boyer.)

But traction (direct) of the head, especially when combined with rotation, is peculiarly dangerous in children, on account of its liability to cause luxation of the first vertebra upon the second. Several cases are reported where children, in turning somersaults, dislocated the first upon the second vertebra; and Marjolin states that in very young persons the odontoid process is so short that it may pass behind the transverse ligament, without rupturing the latter. (Ashhurst.) In young subjects, the odontoid process being yet incompletely developed, and the odontoid ligaments being proportionally longer and less firm, traction directly applied to the head with rotation, may stretch and break these ligaments and their accessories, so as to permit the odontoid process to pass under the transverse ligament and crush the spinal cord, without rupturing that ligament. J. L. Petit saw a child, aged 6 or 7, lifted up by a man (in order to see London, according to the vulgar saying), who took hold of the forehead and back part of the head. The child struggled, became agitated, and died. Although no anatomical examination was made, there is little doubt that the atlas was luxated upon the axis. (Boyer.)

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[1] Am. Journal of the Med. Sciences, October, 1871.

[2] New York Sun, July 22, 1882.

An infant, 8 days old, was instantly killed by violence from its mother; Maschka reports that the second cervical vertebra was found dislocated.[1] This case probably belongs to the same category as those mentioned in the last paragraph; and in it, likewise, dislocation occurred between the atlas and the axis, because the odontoid process was so short, from want of development, that it passed under the transverse ligament, as soon as the odontoid or check ligaments had been ruptured.

The *etiology* of luxation at the juncture of the atlas and axis can be further illustrated by referring to 12 examples of it that are mentioned in Professor Ashhurst's tables.[2] Of these, it was caused, in four instances, by falling from a height and alighting on the head; in two instances, by suicidal hanging; in one instance, by the fall of a bundle of hay upon the head; in one instance, by blows on the back of the neck; in one instance, by muscular action; while in three cases, the form of the injury is not stated. It is worthy of remark that there is no mention, in Professor Ashhurst's tables, of any instance where this lesion was caused by the hanging of criminals according to law, although it is well known that this lesion is often present in such cases. The probable reason for this absence of mention is the fact that such cases are but seldom reported in the medical journals. Hospital reports, likewise, but seldom contain any examples of luxation of the atlas upon the axis, because the victims of this accident generally do not survive long enough to get into a hospital.

But, dislocation at the juncture of the first and second cervical vertebræ sometimes occurs *spontaneously*, in consequence of disease having destroyed the ligaments of the threefold articulation. I have already mentioned a remarkable example of this sort (page †24) which was recorded by Mr. Hilton.[3] In such cases, the head and the atlas together fall forward; and thus the spinal cord may be crushed or strongly compressed by the latter against the odontoid process of the axis which remains fixed. In this way, Mr. Hilton's patient was almost instantly killed. Duverney met with a case in which the atlas had fallen forward so far, in consequence of the destruction by disease of the atlo-axoid ligaments, that the odontoid process was approximated to the posterior arch of the atlas by two-thirds of the diameter of its foramen spinale. (Boyer.)

Furthermore, dislocation of the atlas upon the axis, whether caused by injury or by disease, does not prove immediately fatal unless the displacement of the former be so great that its posterior arch crushes, or strongly compresses, the spinal cord against the odontoid process of the latter. In cases where the displacement of bone is not so great as to seriously compress the cord, however, life may be prolonged for many hours or many days, and even recovery may take place. For example:—

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[1] New Syd. Soc. Year-Book, 1859, p. 427.

[2] Op. cit., pp. 72–121.

[3] Op. cit., pp. 61, 62.

A mason, aged 60,[1] fell head-foremost from a height. He suffered from shock, and there was unnatural mobility of his head. He survived the accident, however, twenty hours. An *autopsy* showed dislocation forward of the atlas on the axis; no fracture; the spinal cord was compressed by the odontoid process. (Ashhurst.) Again, a boy, aged 15,[2] was injured by blows on the back of the neck, but paralysis did not supervene until four months afterward. One-half of a month later still, death ensued. An *autopsy* revealed dislocation forward of the atlas, with compression of the spinal cord. (Ashhurst.) Moreover, in two cases mentioned in Professor Ashhurst's tables, where "dislocation or displacement of the atlas" was diagnosticated, reduction by extension, etc., proved successful; and in one case of "dislocation of the odontoid process" recovery also is stated to have taken place.[3]

In the case of a female patient, aged 45, where there was at least subluxation of the atlas from disease of the atlo-axoid articulation, Mr. Hilton says: "The head was inclined to fall forward, and, indeed, she found it impossible to keep it up without artificial support of some kind. On pressing the head directly downward upon the spine, and attempting to rotate the head upon the spine, she could not bear it. She became nearly pulseless and fainted, and the limbs tremulous and agitated. We immediately placed her upon the floor of the room. I thought she was dead, but she very slowly recovered."[4]

Still, this patient, in the end, regained good health after many months of treatment, which consisted mainly in absolute rest of the spine in bed with two large half-filled bags of sand placed, one on each side of the head and neck, to prevent any lateral movement of the head, and a small, firm pillow put under the neck, to remedy the displacement of the atlas by raising the axis to the same level, thereby freeing the spinal cord from the impingement upon it of the odontoid process of the axis. The last-mentioned point in the treatment is of very great importance. Concerning it Mr. Hilton observes:—

"The patient was placed with her back flat on her bed. This position brought on extreme difficulty in her breathing. Whilst she was still in the recumbent position, and breathing with difficulty, I placed my hand underneath the neck, and lifted upward and forward that part of the spine. The sense of suffocation became at once diminished (I had observed the same circumstance before in another patient who had disease of the highest part of the spine), and I had therefore a small, firm pillow put underneath the neck, which supported it very perfectly. This is a very important fact, because I think I have known at least two persons who were destroyed in consequence of this little point not having been attended to."[5]

Considerable space has been devoted to this example because of its intrinsic value in showing what the plan of treating this lesion should be, in cases of injury where life is not immediately destroyed, as well as in cases of disease.

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[1] Journal de Chirurgie, 1844.

[2] Revue Médico-Chirurg., t. xii.

[3] The two instances, that are barely mentioned above, in which traumatic dislocation of the atlas was successfully treated by reduction, deserve additional notice: (1) A man, aged 60 (Malgaigne, Traité des Fract. et des Luxations, t. ii.), was injured by a bundle of hay falling on his head. His head was bent forward so that his chin touched the sternum, but there was no paralysis. A dislocation of the atlas was diagnosticated. Malgaigne (Senior) reduced the dislocation by making extension, and the man recovered. Two years afterward his head could not be turned. (2) A lad, aged 16 (Journ. Complémentaire, t. xxxvi.), fell backward from a ladder, with a sack of flour over his head. He was unconscious, almost pulseless, and paralyzed. There was abnormal mobility of the head, and a prominence in front and to the left of the point of abnormal mobility. A displacement of the atlas was diagnosticated. Ehrlich effected reduction by applying extension and pressure. The success of his efforts was marked by an audible sound. Recovery ensued.

[4] Op. cit., pp. 56–60.

[5] Ibid., p. 58.

Dislocation forward of the axis upon the third cervical vertebra, without fracture, carrying the atlas and the head forward with the axis, has been reported in a few instances. In the following example, where pure luxation of the second upon the third cervical vertebra was found, partial paralysis of the left arm and forearm was noted, while the lower extremities and the bladder were entirely free from paralysis ; but death suddenly occurred on the fourth day :—

The case was that of a man, aged 34.[1] On the patient's admission to hospital, there were observed paralysis of the left deltoid muscle, and impaired power of supination of the left forearm, showing involvement of the left circumflex and musculo-spiral nerves. All the movements of the lower extremities, however, were perfect, and the patient had complete control over the bladder. But he became restless, and threw his limbs about ; and died suddenly on the fourth day, while struggling and kicking. At the *autopsy* a dislocation of the second from the third cervical vertebra was found, with very extensive extravasation of blood behind the pharynx and œsophagus, uncomplicated with fracture. Mr. Erichsen remarks on the great rarity of the case. There were no head-symptoms, and there was also no general paralysis. Stress is laid on the absence of any hyperæsthetic line during life, as indicating that the lesion was a dislocation rather than a fracture, because the broken sharp edges of bone in a fracture would irritate the spinal nerves in contact with them, and thus cause hyperæsthesia in the tract supplied by the irritated nerve-fibres.

It is not improbable that this man's sudden death was caused by sudden compression of the spinal cord, resulting from a sudden increase in the displacement forward of the second cervical vertebra, which was occasioned by the restlessness and tossing of the patient himself. In treating such a case, confinement to bed in the recumbent posture from the outset, with a small, firm pillow placed under the neck, and a large, half-filled bag of dry sand moulded to each side of the head and neck, as recommended by Mr. Hilton in treating luxations of the upper cervical vertebræ from disease, would be of inestimable value, and would probably lead to the patient's recovery as well as prevent the occurrence of sudden death.

Another example of this accident may be briefly reported as follows :—

A man, aged 50,[2] fell backward from a fence and struck upon his head, sustaining thereby a dislocation of the second from the third cervical vertebra. His head was thrown back, and there was paralysis, but no pain. Attempts at reduction failed ; and, in forty-eight hours, he died. (Ashhurst.)

Pure luxations at the juncture of the second and third cervical vertebræ are extremely rare ; and I have found only the two examples just presented. One reason why these cases very seldom come under treatment, possibly is the fact that the vertebral displacement is very liable to cause instant death, at the time of the accident, by strongly compressing or crushing the spinal cord above the origin of the phrenic nerves. But, in the examples which do come under treatment, it may sometimes be a remedial measure of very great importance to effect a reduction of the displacement, especially if the paralysis be extending or threatening to become complete paraplegia. In such a case, the efforts at reduction should be persisted in until they achieve success.

The next case is of interest mainly because it shows that death by hanging may be attended with luxation at the juncture of the second and third cervical vertebræ, as well as with fracture of the second :—

Mahon[3] found in a female criminal, on whom the death-sentence had been executed by hanging, that the axis was fractured, and that the intervertebral cartilage between the axis and the third cervical vertebra was ruptured. (Ashhurst.)

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[1] Lancet, August 1, 1874. Some remarks thereon by Mr. Erichsen are also presented.

[2] Boston Med. and Surg. Journal, vol. x.

[3] Méd. Légale, t. iii.

Dislocations of the last five cervical vertebræ (that is, of any vertebra from the third to the seventh inclusive) from violence, without fracture, frequently come under the care of surgeons. For example, of 36 fatal cases of injury of the cervical vertebræ extracted from the records of Guy's Hospital prior to 1878, 11 were examples of pure dislocation, all of them below the third cervical vertebra; and the remaining 25 were instances of dislocation combined with fracture.[1] Pure dislocation below the third cervical vertebra is therefore met with in about 30 per cent. of all the cases in which traumatic lesions of the cervical vertebræ occur; and, in the rest of them, the dislocation is generally combined with fracture.

Again, of these 11 examples of pure dislocation, 4 were found between the fourth and fifth cervical vertebræ; 2 between the fifth and sixth; 3 between the sixth and seventh; and 2 between the seventh cervical and the first dorsal vertebra. In 6 of them, the displacement was so great as to crush the spinal cord. In 5, there was no marked paralysis as a direct result of the injury, although secondary paralysis subsequently appeared, from stretching or other injury of the cord, and proved fatal. In none of them was there even the smallest trace of fracture.

Death generally ensued within seventy-two hours in those cases of cervical dislocation where the spinal cord was injured enough to cause paraplegia; and, in a majority of the instances, within forty-eight hours. For example, 28 of the 36 fatal cases observed at Guy's Hospital died in less than seventy-two hours, and 20 in less than forty-eight hours; 8 only survived the former period, and in them no symptoms of paralysis resulted immediately from the accident. (Bryant.)

In every one of these cases of cervical dislocation, the upper vertebra was thrown forward upon the lower, and the intervertebral cartilage connecting them was ruptured. In the luxations that occur among the last five cervical vertebræ, then, as well as in those that have already been described, the displaced bone carries with it the whole of that portion of the spinal column which is placed above it, no single vertebra being simultaneously dislocated from those above, as well as from those below it. When spinal symptoms result in these cases, the cord is generally found to be injured by the displaced bone; in some instances it is crushed, in others bruised, and in others merely compressed.

The following case, with the accompanying wood-cut (Fig. 009), will afford a good illustration of the disjointings which are met with among the last five cervical vertebræ:—

Private John F., Co. B, 2d Infantry, a powerful, muscular German, aged 35, was badly hurt by falling on his head while attempting to turn a somersault, on February 10, 1866. Instead of alighting upon his feet, his head struck the earth, and he rolled over upon his side and lay motionless; face pale, respiration sighing, pulse slow and full. Examination showed that sensation and power of motion were alike wanting from the neck downward. The walls of his chest were motionless, and respiration was effected by the diaphragm alone. He moved his head freely from side to side, but could not raise it. On lifting his head from the table, so much distress ensued that the effort was abandoned, and he was turned partly upon his side, in order to examine the neck. But the examination was very unsatisfactory, for the layers of muscles and fat were so thick that the spinous processes could not be distinctly perceived, and a positive diagnosis could not be arrived at. It was clear, however, that there was an abnormal gap or depression between the spinous processes of the fourth and fifth, or the fifth and sixth, cervical vertebræ; that pressure on this depression gave slight pain; that crepitus was absent; and, that the movements of the head upon the atlas, and of the atlas upon the axis, were such as to prove that these articulations were not involved.

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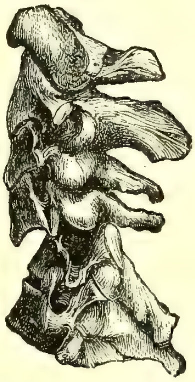
[1] Bryant, Practice of Surgery, Am. ed., 1879, pp. 201, 202.

The respiratory movements indicated that the lesion of the spinal cord was below the origin of the phrenic nerves, and the total paralysis of the upper extremities that it was situated above the origin of the brachial plexus. The patient, thenceforth, was left undisturbed. He lay perfectly supine, breathing by the diaphragm alone, suffered no pain, and was able to swallow small quantities of fluids. His pulse which immediately after the accident was 78, in two hours fell to 72. About three ounces of turbid urine were withdrawn by catheter in the evening. He sank gradually, and died forty-four hours after the accident.

Fig. 772.



Luxation forward of the fourth cervical vertebra upon the fifth. Spec. 549, Sect. I., A. M. M. The four upper cervical vertebræ are displaced far forward, and the axis of the vertebral column is also abruptly bent in the same direction at the place of luxation.

Autopsy, five hours after death. Rigor mortis imperfectly established; sugillation general over posterior portion of body; ulceration over the sacrum had already commenced. The lower and back part of the neck exhibited slight tumefaction, yet sufficient to obliterate the depression which had been felt during life. The whole cervical portion of the spinal column was exposed by dissection, which revealed a dislocation forward of the fourth cervical vertebra upon the fifth. (The accompanying wood-cut, Fig. 772, clearly shows that the fourth cervical vertebra was dislocated from the fifth, and not the latter from the former, as stated in the report of the case.) The luxation was "symmetrical." There was a wide interval of one and a half inches between the spinous processes of the fourth and fifth vertebræ, which caused the depression perceived at the first examination of patient. There was no fracture of the body, pedicles, or laminæ of the displaced bone, but a part of the anterior tubercle of the right transverse process of the fifth vertebra had been snapped off. The ligamenta subflava and capsular ligaments connecting the fourth and fifth vertebræ had been ruptured, as well as the attachment of the ligamentum nuchæ to these bones. The anterior and posterior common ligaments were not broken. There was a slight extravasation of blood external to the theca vertebralis, and a considerable quantity between the theca and the spinal cord. At the point of luxation, the cord was bent at an abrupt angle, and its antero-posterior diameter reduced more than one-half by compression from the laminæ of the displaced fourth vertebra against the body of the fifth, and by tilting forward of the upper four vertebræ. The meninges of the cord were not torn, nor was the cord itself lacerated, which may perhaps be accounted for by the fact that the wide separation of the laminæ posteriorly allowed it to bulge out in that direction, and thus escape rupture. The lungs were generally congested, the left more than the right. The posterior portions were especially engorged; but crepitation was nowhere entirely absent. The heart was slightly hypertrophied and all its cavities empty. The osteal specimen was removed and sent to the Army Medical Museum. It is represented in Fig. 772.[1]

The symptoms in this case clearly indicated that there was dislocation forward of a vertebra, with much displacement, somewhat below the middle of the cervical region, without much fracture. The completeness with which the skin and all the muscles below the neck, excepting the diaphragm, were paralyzed, denotes that the spinal cord was either severed or strongly compressed by the displaced bone. The autopsy showed that the antero-posterior diameter of the cord was lessened more than one-half by displacement forward of the fourth vertebra, and that the compression of the cord thus caused was supplemented by the extravasation of considerable blood between the theca and the cord. It is not improbable that the extravasation of blood, if it did not directly occasion, hastened by at least some hours the occurrence of death, by compressing the spinal cord at and above the origin of the phrenic nerves. It should here be stated that, in vertebral dislocations and fractures, blood is often extravasated in large quantity between the theca and the cord, and that such extravasation proves to be the proximate cause of death by compressing the cord.

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[1] Circular No. 3, S. G. O., August 17, 1871.

A case with many points of resemblance to the foregoing was treated some years ago by myself:—

A robust man, aged about 30, while driving a peddler's wagon having a very high seat, into a carriage-house having a rather low door, struck the back of his head with great force against a beam at the top of the doorway, which crushed him down into the seat. He instantly became helpless and was carried into the house. Two hours afterward I saw him; he then lay in bed on his back, with his neck bent forward and stiff, and he seemed to dread lest an attempt to raise his head should be made; he could, however, roll his head freely from side to side. His lower extremities, body, and upper extremities were completely paralyzed, both as to sensation and motion. His mind was clear, and he said he was free from suffering. He was breathing by the diaphragm alone, for all the other respiratory muscles were paralyzed. By turning his body on to the left side I was enabled to examine the back of his neck, which was thick, muscular, and somewhat swollen. The spinous processes of the fifth and sixth, or sixth and seventh cervical vertebræ (I was not quite sure which) were widely separated from each other, and the vertebræ above the point of separation were thrown forward. The abrupt bending of his neck forward, above mentioned, resulted from the wide separation of the spinous processes and laminæ behind, and the thrusting forward of the body of the dislocated vertebra and those above it. I took it for granted that some fracture was also present, but it seemed to be the dislocation alone which caused the deformity, the displacement of bone, and the compression of the spinal cord. I catheterized him, and then noticed that he had partial erection of the penis, or priapism. He was placed in a soft bed and a milk-diet allowed. The attendants were cautioned against injuring his neck while giving him food or drink. The accident happened in the afternoon.

The next morning it was observed that sensibility had partially returned to his arms, but the paralysis as to motion was still complete; in other respects his condition was unchanged. The urine was now drawn off with a catheter, and again in the evening.

The following day did not bring any signs of improvement. The urine had a strong ammoniacal odor. The bowels had not moved. The abdomen was swollen by gases in the intestines. A terebinthinate enema was administered. Catheterization twice a day was continued.

On the third morning he was much worse. His respiration was difficult, the movements being much increased in frequency, and accompanied by moist rales. His lips were becoming blue; he was tympanitic; he sank rapidly, and died asphyxiated, seventy hours after the accident. An autopsy could not be obtained.

Another case, almost the exact counterpart of the last, I once saw in consultation with the late Dr. Jenks S. Sprague, formerly president of the New York State Medical Society:—

A healthy, middle-aged farmer fell backward from the top of a loaded hay-wagon, and struck the ground with the back of his head and neck, the whole weight of his body being superimposed. He was instantly deprived of the use of all his limbs. He was picked up, in a helpless state, and carried to his home, where the writer saw him as consultant, as stated above, a few hours afterward. He was completely paralyzed both as to sensation and voluntary motion, up to the root of the neck. The head and neck were considerably inclined forward, the latter being stiff. The spinous processes and laminæ of the last two cervical vertebræ were widely separated from each other, and the sixth vertebra was dislocated forward, so far that its laminæ strongly compressed the spinal cord against the body of the seventh. The presence of fracture was suspected, although no crepitus nor movable fragments of bone could be detected. The head rotated well at the atlo-axoid articulation. He lay on his back and breathed by means of the diaphragm alone. Catheterization was necessary. There was priapism. His intellect was not disturbed, and he said that he was free from pain.

The symptoms and progress of this case bore so close a resemblance to those attending the last, that it is not worth while to describe them. He also died, asphyxiated, on the fourth day; autopsy not allowed.

In both of my cases, the wide gap or interval which marked the separation of the spinous processes of the two vertebræ particularly injured, the displacement forward of the upper one, and the abrupt bend in the axis of the spinal column, forward, at the point of separation between these two vertebræ, with the stiffness of the neck, denoted that the first bone above that point, together with all the cervical vertebræ resting upon it, was dislocated forward, while the rest of the spinal column remained fixed or unmoved. Although no crepitus nor fragments of broken bone could be detected, it still was supposed that some degree of fracture, perhaps but slight, was also present, inasmuch as dislocations of the cervical vertebræ are complicated by fracture in a large majority of instances. Nevertheless, it is quite possible that both dislocations were uncomplicated or pure. However this may be, it is quite clear that, in each instance, the compression of the spinal cord was caused by the displacement forward of the dislocated vertebra; and that the indication for treatment, if the cases had not been regarded as almost hopeless, would have been to free the cord from compression by putting the dislocated bone back into its natural place. In reflecting upon these cases, I have often regretted that I did not make trial of reducing the dislocation, under anæsthesia, at least in the case of the peddler, the improvement in whose symptoms on the second day indicated that the cord was not irreparably injured. On the next day, however, his symptoms were all worse, and the prognosis hopeless. Had I this case now to treat, I should, as soon as it became clear that the man would not recover under an expectant plan of treatment, that is, on the second morning after the accident, relax his muscles completely by administering an anæsthetic, and then, by carefully made extension and rotation, etc., proceed to restore the dislocated bone to its normal position. In pursuing such a course, I would be guided by the following considerations: (1) The almost absolute certainty of a fatal termination in this class of cases, within two or three days, if an expectant plan of treatment be followed. Of 36 perfectly analogous cases treated at Guy's Hospital, all died within seventy-two hours. (2) The fact that some strictly analogous cases have undoubtedly been saved by reducing the dislocation. Three examples of recovery, by means of reduction, from symmetrical dislocations occurring among the last five cervical vertebræ, that were apparently hopeless, are mentioned in Professor Ashhurst's tables. It is stated that, in one of them, the patient, a woman, was already unconscious, and her heart had nearly stopped; and, that in another, where reduction was effected forty hours after the accident, by extension, the patient had been unconscious for half an hour, that there was dyspnœa, and that death was imminent; the success of the manœuvre was indicated by an audible "snap." (3) The effort to reduce the dislocation should be made as affording the sole, and, at the same time, a not unreasonable prospect of saving the patient's life. I therefore would delay the attempt at reduction, in such extreme cases, until the symptoms denoted that the patient was rapidly going from bad to worse, as intimated above.

Dislocation of some one of the last five cervical vertebræ may be caused while bathing, by striking the back of the head upon the ground in diving, as happened in the following instances:—

A soldier, aged 25,[1] struck his head in this manner while bathing. Paralysis, etc., appeared, and dislocation of a cervical vertebra was diagnosticated. Death ensued in twenty-three days. The posterior ligament between the third and fourth cervical vertebræ was found to be ruptured. (Ashhurst.) A similar accident happened to a sailor, whose case is reported by J. Roux. He plunged head-foremost into the sea for the purpose of bathing, and was injured by striking against a sail which had been sunk to prevent the attack of sharks; on the fourth day he died. In both of these cases the dislocation was doubtless caused by forcibly bending the head and neck forward upon the chest. This summer (1882), while I write, several instances of cervical dislocation, caused by diving in shallow water and striking the head against the ground, have been reported at Coney Island, where, this season, multitudes greater than ever are said to bathe.

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[1] Am. Medical Times, vol. vii.

Etiology.—The examples presented above, as well as many cases on record which have not been presented, show that symmetrical dislocations of the vertebræ, at the middle and lower part of the cervical region, are generally caused by powerful flexion of the neck upon the chest, from falling upon or striking against the back of the head with great force, "though traction and rotation conjoined have occasioned them." There is also one case on record in which the mode of injury is said to have been a blow, struck upon the neck of a drunken man, aged 30, which caused him to fall. Reduction was effected by extension, under chloroform, on the tenth day, by Dr. Ayres, of Brooklyn, N. Y., and the patient recovered. Dupuytren, too, reports a fatal case, in which dislocation forward of the fifth cervical vertebra, with fracture of the sixth, was produced directly by a plank striking on the neck.

Among the *predisposing* causes of dislocation in the cervical region are: (1) the remarkable mobility of the cervical vertebræ upon each other; (2) the obliquely horizontal position of their articular processes; and, (3) the nearly horizontal direction of their spinous processes. Moreover, these anatomical peculiarities likewise strongly favor the occurrence of dislocation, without fracture, in the cervical region.

Fracture of the sternum is not unfrequently associated with the injuries of the spinal column which are caused by the forcible bending forward of the head. Mr. Bryant says that it was found in four instances among the fifty-six fatal cases of spinal dislocation and fracture which were observed at Guy's Hospital.

Diagnosis.—The symptoms and course of symmetrical or bilateral dislocations of the vertebræ, when they occur at the middle or lower part of the neck, are clearly set forth by the examples that have just been presented.

1. Whenever the bones which enter into the formation of the vertebral joints are dislocated, deformity ensues, for the same reason that it does when other bones are dislocated, for instance, those of the extremities; and although the cervical vertebræ are covered by thick layers of muscular tissue, etc., the deformity which results from a bilateral dislocation of these bones can always be perceived, if the examination be conducted with sufficient care and skill. Of course, the deformity will vary according to the direction and extent of the displacement of bone. But, generally, the displaced bone, together with all the vertebræ surmounting it, is thrown forward in such cases. Oftentimes the spinous process of the dislocated vertebra is separated from the spinous process of the next vertebra below it, or that from which it is dislocated, by a distance of one and a half or even two inches; and, in consequence of this separation, a wide gap, with a corresponding depression of the soft parts, may be felt between them. In such cases, the head is usually thrust forward, and the axis of the spinal column also bends abruptly forward at the place of injury. At the same time, the mobility of the vertebral joints that are involved is more or less completely destroyed, and all attempts to produce motion in them cause corresponding pains. Not unfrequently, in cases where the cervical vertebræ are injured, it is concluded that certain joints belonging thereto are not luxated, from the fact that their mobility is not impaired; for

instance, it is shown by nodding and rotating the patient's head that the luxation (if any) is not at the atlo-axoid articulation, but somewhere below it. Oftentimes, too, the body of the disjointed vertebra can be felt bulging forward into the pharynx, and this point in the examination is an important one to look after. As a rule, in these cases, the abnormal position of the salient points of the dislocated bone, as well as the rigidity and painfulness of the injured articulations, can readily be detected by a manual examination. But if there be preternatural mobility, and especially if there be crepitus felt in connection with the displaced bone, it will be strong evidence that fracture is present as well as luxation.

2. If, in cases of cervical dislocation, the spinal cord be not compressed by the displaced bone, nor otherwise injured, there will at first be no paralysis, and no subjective symptoms whatever, excepting the immobility, soreness, and painfulness of the disjointed articulations. In such cases, however, spinal paralysis may subsequently appear, and death ensue. Several instances of this sort are on record. For example:—

Caussé[1] gives the case of a man who injured his neck by falling from a chariot on to the wheel. There was at first no paralysis; only stiffness of neck and pain on bending it. On the third day, however, in turning his head he felt a crack, and became paralyzed. Death ensued, and complete forward dislocation of the fifth cervical vertebra was found. (Ashhurst.) It is not improbable that, in this case, the luxation was incomplete at first, but became complete on the third day, in consequence of the accident sustained in turning his head.

Dupuytren likewise reports the case of a mason, aged 49, who fell backward down stairs, striking his head on a step; a bag of plaster came upon his breast. In consequence, his head was thrown forward and to the right, his neck was stiff, and the spinous processes of the fourth and fifth cervical vertebræ could not be felt, while their transverse processes were abnormally prominent. At first there was no paralysis, but afterwards it came on, and in ten hours death ensued. The fifth cervical vertebra was found displaced forward with fracture of its processes, and the spinal cord was divided. It is not improbable that in this case, too, the luxation at first was incomplete, and the spinal cord being not compressed there was no paralysis; but, in a few hours, it became complete, because the cord was divided, perhaps from injudicious attempts to examine or to remove the patient, and then paralysis immediately appeared. The paralysis must have increased rapidly, for death soon ensued.

In analogous cases, when spinal paralysis does not appear, recovery may take place. For example: Greenhow[2] reports the case of a female, aged 25, who fell thirty feet, striking the head. She sustained dislocation of three or four upper cervical vertebræ, and was insensible for three days, *but had no paralysis.* There was a scalp wound and fractured clavicle. She was under observation fourteen days, and recovered, but the deformity remained.

Again, Professor Hamilton[3] mentions the case of a man, aged 40, who was thrown from a wagon, striking the back of his neck. He was stunned for several hours; then paralysis came on. However, he did not die; but, after nine months, the spinous process of the seventh cervical vertebra was still displaced to the left side. His head also was bent forward and his neck was stiff; he could walk a few steps, but with fatigue; he likewise had pain in the legs, etc. (Ashhurst.)

But if, in cases of cervical dislocation, the spinal cord be slightly compressed, or slightly bruised, or slightly torn, there will from the outset be paralysis of the parts to which the injured nerve-filaments are distributed. Several cases belonging to this category, whose issue was fatal, are on record. It is not necessary to reproduce them.

Finally, if the spinal cord be crushed or strongly compressed at the middle or lower part of the cervical region by a dislocated or a fractured vertebra, there will be paralysis embracing the whole of the body excepting the head and neck, priapism, retention of urine and feces, flushed face, calor mordicans, diaphragmatic breathing, dyspnœa, and in a short time death from asphyxia. Several cases in point have already been presented. For diagnosticating the lesion itself, however, the paralysis in these cases is of no practical value, inasmuch as it may result from concussion of the spinal cord, and from the effusion of blood, or of the products of inflammatory action upon the cord, as well as from the displacements of bone which attend vertebral dislocations. But, for *prognostic* purposes the paralysis in such cases is of great value.

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[1] Mémoire Médico-légale, etc.

[2] Lancet, 1851.

[3] Op. cit.

The signs, then, by which a bilateral dislocation of a cervical vertebra in the middle or lower part of the neck may be recognized, consist of the physical evidences of the displacement itself, the absence of the symptoms which characterize fractures, such as crepitus and unnatural mobility of the vertebra in question, or of some part thereof. But, inasmuch as vertebral fracture may occur without being attended by crepitus or suspicious mobility, especially if the fracture be but slight, we never can positively assert of any case of cervical dislocation, during life, that it is entirely uncomplicated by fracture. Thus, it appears, that while the diagnosis of vertebral dislocation (bilateral) at the middle or lower part of the neck is, in general, not very difficult, the diagnosis of slight fracture simultaneously involving the same bones, is often impossible during life. This, however, is not a matter of much practical importance, since the perils of the case depend upon the injury of the spinal cord, which results mainly from the displacement of bone that is due to the dislocation ; and to this point the attention should first be directed in treating the case.

Prognosis.—Luxations of the vertebræ are more dangerous to life than the luxations of other bones, on account of the great risk there is that the spinal cord and spinal nerves will be directly or indirectly injured thereby, and that spinal paralysis will ensue. Luxations of the cervical vertebræ are more dangerous than luxations of the dorsal and lumbar vertebræ, on account of the great risk there is that the chief respiratory muscles, the serratus posticus superior and inferior, the serratus magnus anticus, the diaphragm, etc., will be paralyzed thereby, and that death from asphyxia will immediately ensue.

When the spinal cord is crushed or strongly compressed *above* the third cervical vertebra, in cases of spinal dislocation or fracture, life is instantly destroyed, because the chief respiratory nerves, to wit, the two phrenic, the four thoracic, and the respiratory branches of the intercostal nerves, from having their several origins in the cord below that point, instantly cease to act (as do all the spinal nerves that originate in or pass off from the cord below the same point), and therefore the muscles to which they are distributed instantly cease to perform the respiratory movements.

When the spinal cord is crushed or strongly compressed *below* the origin of the phrenic and long thoracic nerves, in cases of cervical dislocation or fracture, death will generally be deferred for some little time, although the whole body, excepting the head and neck, will be paralyzed in respect to sensation and voluntary motion. In such cases, the respiratory function is maintained by the action of the serratus magnus anticus and the diaphragm alone.

In cases of dislocation or fracture of the spinal column above the third cervical vertebra, experience has shown that life is often instantaneously destroyed. In cases of dislocation or fracture below the third cervical vertebra and above the first dorsal, where the cord is so much injured that there is motor and sensory paralysis of nearly the whole body excepting the head and neck, and the respiratory process is maintained solely by the diaphragm and serratus magnus, life is seldom prolonged more than 72 hours, and, as a rule, not above 48 hours. In one of Dupuytren's cases, that has just been mentioned, death ensued in 10 hours; and Professor Hamilton refers to an instance of complete dislocation of the fifth cervical vertebra, without fracture, in which death occurred in 2 hours. But, on the other hand, Mr. Bryant mentions the case of a gentleman, aged 29, with complete paralysis below the fifth cervical vertebra, caused by a fall upon the neck, who was still alive over six years afterward, and breathing by the diaphragm alone. Mr. Hilton, likewise, has recorded the case of a man who lived for fourteen years completely paralyzed from the neck downward, after sustaining a fracture of the fifth and sixth cervical vertebræ. Such exceptions to the rule, however, are very rare.

The prognosis in cases of dislocation or fracture of the cervical vertebræ must be mainly determined by the seat of the lesion, and the amount of damage which the spinal cord has received. Usually, the nearer the seat of the injury is to the respiratory centre, the greater is the danger to life. When, however, no paralysis appears in the case, it will generally end in recovery, for luxations of the vertebræ unattended by lesions of the spinal cord do not seem to be any more hazardous to life than luxations of other bones of a corresponding size. It should not be forgotten, however, that where there is no paralysis at first, it may supervene in a few hours in consequence of the displacement of bone becoming increased, or from the extravasation of blood between the theca and the cord, or from the occurrence of traumatic inflammation of the cord or its membranes. Several illustrative cases have already been mentioned. In the following instance, paralysis and death resulted from traumatic meningo-myelitis:—

Simon[1] relates the case of a woman, aged 18, who fell eleven or twelve feet and was stunned. She walked home, three or four miles, and resumed work for eleven days. Then pain, fever, etc., appeared; and, on the sixteenth day, paralysis. Delirium, "jumping of legs," etc., followed, and, in eighteen days, death ensued. Fracture of the seventh cervical vertebra was found, and the spinal canal filled with pus. (Ashhurst.)

Certain symptoms are considered of peculiarly evil omen in cases of spinal injury. They are a steady increase in the extent or degree of the paralysis, dysphagia, dyspnœa, flushed face, and alteration of the vital temperature. These symptoms, however, and their import, will be discussed further on in this article. Here, I will only mention a single case reported by Brodie,[2] wherein the cervical portion of the spine was injured, and there was paraplegia with diaphragmatic breathing. A thermometer placed between the thighs showed the body-heat to be 111° Fahr. Death ensued in twenty-two hours. Displacement of the fifth from the sixth cervical vertebra was found, and laceration of the cord with effusion of blood in the spinal canal.

The *proximate cause of death* in dislocations and fractures of the lower cervical vertebræ generally consists in a creeping upward of certain morbid processes which have been set up in the spinal membranes, or in the substance of the spinal cord, opposite the vertebral lesion, from the place of primary injury to the roots of the phrenic nerves (above the third cervical vertebra), whereupon these nerves cease to act, the diaphragm ceases to contract, and death from asphyxia ensues. In some cases the morbid process consists in extravasation of blood between the theca vertebralis and the cord, which spreads upward until it compresses the cord at and above the third cervical vertebra, as happened in the case of a soldier mentioned above, who dislocated his neck in vainly attempting to turn a somersault. In other cases, the morbid process consists of an ascending spinal meningitis. In still others, it consists of an ascending traumatic myelitis, and this class is probably a numerous one. People who are fatally injured in the cervical part of the spine, as a rule, do not live long enough to get sacral and gluteal eschars, or bed-sores, nor for vesical and renal disease to occur in consequence of the rachidian lesions.

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[1] Proc. Lond. Path. Soc., vol. vi.

[2] Med.-Chir. Trans., vol. xx.

Treatment of Cervical Dislocations.—Here, it may be well to state again, that in all pure dislocations of the cervical vertebræ, certainly in all that are bilateral or symmetrical, the intervertebral substance is torn through, and the upper vertebra is displaced forward from the lower; that in dislocations and fractures combined, of the last five or six cervical vertebræ, the intervertebral substance is also torn through, and the upper vertebra displaced forward from the lower; and that, in such cases, the fracture is generally found in the spinous process, the laminæ, or the pedicles of the dislocated vertebra, but not in its body. Thus, it is seen that the displacement is strictly analogous, in cases of dislocation combined with fracture, to what it is in pure dislocation, and that the treatment of the former should be substantially the same as the treatment of the latter.

Moreover, in dislocations and fractures of the spinal column, it is not the lesions of the vertebræ, *per se*, which disable and kill, as much as it is the displacement of bone, and the extravasation of blood between the theca and the cord, or into the cord itself, and the consecutive inflammation of cord and membranes, that may attend these lesions; for, by the above-named consequences of spinal injury, the substance of the spinal cord is directly torn, or bruised, or compressed, or disorganized, so that the spinal nervous functions in the segment of the cord below the place of injury may cease entirely to be performed, and the parts dependent thereon for innervation become completely paralyzed. It is, then, the displacements of bone, the intra-spinal extravasations of blood, and the inflammations of the cord and its membranes that attend these lesions, which the surgeon must chiefly consider in conducting the treatment of these cases.

When a person receives, in any way, a dislocation or a fracture of the neck, or of any other part of the spinal column, the first thing of importance to do is to effect the person's removal to hospital or home without producing additional injury. To this end, the patient should be placed in an extended position, on the flat of the back, upon a board, settee, or stretcher, and in that way carried in as nearly a fixed or immovable position as possible. If the lesion be situated above the third cervical vertebra, a small, firmly rolled wad of clothing should generally be placed under the neck in order to keep it raised up, and thus prevent the head from falling forward and dragging with it the spinal cord against the odontoid process of the axis. In such cases, too, the head should be kept steady, and prevented from rolling from side to side.

At the first examination, the surgeon should make the diagnosis as complete and accurate as possible, particularly in regard to the distortion or deformity of the injured parts and the displacement of the injured bones, so that future examinations on these points may be avoided. Should the lesion prove to be a dislocation, whether it be pure or attended by fracture, the question will immediately arise whether it ought to be reduced or not; that is, whether the principal indication in the treatment of dislocations in general ought to be fulfilled in treating vertebral dislocations, or not. On this point, which is nearly the main point in the treatment of such cases, the opinions of surgeons have been unhappily divided. Mr. Erichsen says, "Reduction has been effected [with success] in a sufficient number of cases of this kind to justify the proceeding being adopted when the danger is imminent."[1] Dupuytren, on the other hand, affirmed that such attempts were very dangerous, and that he had often known patients to perish while the extension was being made (Hamilton); from which the legitimate inference would follow that reduction was, in such cases, a proceeding too hazardous to be admissible. I have, however, serious doubts as to Dupuytren's assertion being well-founded, for I do not find any case whatever reported in detail, which Dupuytren could personally have known, wherein the patient perished while extension was being made. No instance of the sort is mentioned among the 394 cases which are embraced in Professor Ashhurst's tables, nor elsewhere, as far as I am informed. Moreover, an inspection of Professor Ashhurst's tables clearly shows that "in the treatment of dislocations in the cervical region, the mortality has been nearly four times greater when constitutional or general treatment has been relied on exclusively, than when attempts have been made to reduce the dislocation by extension, rotation, etc."[2] An inspection of the same tables also shows that in the treatment of dislocations, in the whole spinal column, "the proportion of deaths has been almost three times as large when general treatment has been exclusively used as when extension has been employed. The results of those cases which have survived have also been, as a rule, more satisfactory after extension than without it."[3] I have already mentioned several instances in which reduction was successfully employed in the treatment of cervical dislocations, in some of which recovery would otherwise have been utterly hopeless.

It seems to me that the inference is fairly warranted, from the foregoing considerations, that extension (combined, of course, with rotation or pressure as required) should be employed in every case of spinal dislocation, or of spinal fracture with dislocation, where the spinal functions are disturbed. When the diagnosis is not clear, it will be better to adopt this mode of treatment than to reject it, and I should be disposed to try it in every case where either shortening or marked angular displacement was found. (Ashhurst.) It seems to me, also, that in recent years the current of surgical opinion has, with justice, strongly set in favor of treating spinal dislocations, those with as well as those without fracture, by reducing them. Professor Porta, after carefully analyzing twenty-seven cases in point, comes to the conclusion that the first indication in the treatment of vertebral dislocations as in that of other dislocations, is to reduce them. Mr. Bryant (1878) says: "I have seen several cases in which marked relief was afforded by this course, and the records of surgery contain many more. Practised with discretion, extension of the spine is doubtless a valuable means of treatment."[4] Whenever it is applicable, the best plan of effecting reduction consists in making extension and counter-extension by the gradual traction of assistants, whilst the surgeon endeavors to effect manual replacement. Generally the patient's muscles should be kept relaxed by anæsthetics during the operation. In all cervical cases where the dislocation is disposed to return, extension should be continued for some days after the operation, by means of a weight of about three pounds attached to the patient's head with strips of plaster, and a band to suspend it from the head of the bed. By so doing recovery might have been effected in a case mentioned by Malgaigne:—

A man was injured by a weight falling eight or ten feet, upon his neck. There was no paralysis, but the injured part of the neck was stiff, and moving it caused great pain. Delirium appeared on the third day; and, in five days after the accident, the man died.

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[1] Science and Art of Surgery, p. 293, Am. ed. 1854.

[2] Op. cit., p. 64.

[3] Ibid., p. 66.

[4] Op. cit., p. 204.

Incomplete luxation with fracture of a cervical vertebra was found. It had been reduced, but the displacement had been reproduced, as the autopsy showed.

Mention should not be omitted of a recent case, reported by Dr. Landon Carter Gray, of Brooklyn, N. Y., in which a dislocated third cervical vertebra was successfully reduced, after four months' malposition:—

A boy, aged 15,[1] injured his neck by falling on his head in a vain attempt to turn a somersault. For thirteen weeks after the dislocation, there was only a difficulty in deglutition. Then, the phenomena came fast and many. First, a vesical paresis; next, a numbness of the upper extremity; then, a numbness of the right leg; then, a motor paralysis of both upper and lower extremities; and finally, when he came under treatment, there was found, though the relative dates of the appearance could not be ascertained, a paresis of the left face, tactile anæsthesia of the left upper and lower extremities, an occasional tremor, exaggerated tendon-reflex (although there had been no hasty micturition), and contractures of certain muscles of the neck and shoulders.

On the back of the neck, over the third vertebra, a projection about as large as a pigeon's egg was found. Pressure upon it caused some pain around the point of pressure, but none was felt at the front or side of the neck. The spinous process of the third vertebra deviated markedly to the right. By inserting a finger into the mouth, horizontally backward on a level with the upper surface of the tongue, a distinct depression could be felt in the posterior pharyngeal wall, corresponding to the third cervical vertebra. In order to effect reduction, the boy was laid flat on his back on the table, and etherized until all his muscles were well relaxed. Grasping the head by one hand placed upon the occiput and the other on the brow, both hands being covered by those of an assistant, and counter-extension being firmly maintained, extension was steadily made upward to what was deemed a proper degree, and then the head was slowly and cautiously rotated from left to right. It was necessary to make this rotation three several times before the bone went into place, each rotation, however, effecting evident improvement, although no tendinous snap was heard at any time. But go into place it did, and without the manifestation of any dangerous symptom.

All the morbid phenomena immediately disappeared; and although they returned somewhat after a reluxation following violent emotion, a second reduction caused a permanent cure.

The formidable nature of the spinal lesion, and the happy issue of the operative treatment, render this case a very instructive one to the surgical student; and the clearness and brevity with which the symptoms and the operative procedures are set forth, must prove equally attractive. Moreover, this case shows that dislocations of the cervical vertebræ, even when the displacement of bone is not sufficient to seriously compress the spinal cord, are always accidents of considerable importance, because of the deformity and debility of the injured part which always result; but, more especially, because of the morbid action, not unfrequently inflammatory, in the spinal meninges and in the spinal cord itself, which may ensue. An ascending myelitis sometimes, perhaps often, has this origin.

Several additional cases of symmetrical luxation of the cervical vertebræ, more or less complete, which have been successfully treated by reduction, also require brief mention in this place: (1) The late Dr. James R. Wood, of New York,[2] had a case of partial dislocation of a cervical vertebra, occurring in a child; reduction was effected, and recovery followed. (Ashhurst.) (2) A sailor, aged 46,[3] fell forward on the right side of his head, and sustained a dislocation of the fifth and sixth cervical vertebræ [with fracture?]. There was pain, crepitus, and partial paralysis. The luxation was reduced by extension and rotation, and the paralysis instantly disappeared. (Ashhurst.)

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[1] Annals of Anat. and Surg., February, 1882; Am. Journ. Med. Sciences, April, 1882, pp. 590, 591.

[2] Gross's System of Surgery, vol. ii.

[3] Eve, Surgical Cases.

(3) A soldier[1] fell from a horse; he was stunned, and had a cervical vertebra dislocated; mobility of head was noted. Reduction was effected by extension and manipulation. He could walk again in three days, and recovered in eight days. (Ashhurst.) (4) A male child, aged 3½ years,[2] was injured by another child jumping on his back. He fell and had the third or fourth cervical vertebra dislocated, but no paralysis. The luxation was reduced by extension, and recovery ensued. (Ashhurst.) (5) Dr. J. Flögel[3] reports a case in which a subluxation of the cervical vertebræ was successfully reduced.

But, perhaps, the most suggestive example of recovery, by means of reduction, from an apparently hopeless dislocation of a cervical vertebra, is one to which I have barely alluded; it certainly deserves further mention. Hickerman, of Ohio, found in the case of a girl one of the vertebræ dislocated, causing a prominence in the back part of the pharynx, opposite the fourth and fifth cervical vertebræ, and almost completely suspending respiration and the action of the heart. He seized the head of the patient under his left arm and thus made extension, while with the index finger of his right hand he made pressure upon the projection in the pharynx. In about one minute the bone receded under the pressure, and immediately the respiration became natural. Recovery was complete.[4] As already stated, there are several similar cases on record.

In striking contrast with these excellent results achieved by reduction, is the fact that among the 394 cases contained in Professor Ashhurst's tables, no mention is made of even one case of bilateral or symmetrical dislocation of a cervical vertebra, attended with paraplegia from compression of the spinal cord by the displaced bone, in which recovery took place under the expectant treatment, and but few in which death was long deferred.

But the restoration of a cervical vertebra, when luxated, to its normal position, is seldom easy, generally difficult, and sometimes almost impossible to accomplish, as the following examples will help to show:—

Gaitskill[5] is the authority for a case of complete bilateral dislocation of the seventh cervical vertebra, attended by paralysis, which in the upper extremities was only partial. The efforts at reduction failed and the patient died. Mention has also been made on one of the preceding pages of a case of luxation of the second cervical vertebra from the third, reported by Spencer,[6] in which the attempt at reduction likewise failed, and in which, after forty-eight hours, the man died. (Ashhurst.)

These two cases show that the surgeon who attempts to reduce luxations of the cervical vertebræ, must expect to encounter great difficulties at times, and should be prepared to overcome them; this he can generally do by persevering sufficiently in appropriate and well-directed efforts at reduction, while the muscles of the patient are completely relaxed by the inhalation of chloroform or ether.

Having reduced the dislocation, and taken adequate measures (above mentioned) to prevent its recurrence, as well as to provide against the falling forward of the patient's head in such a way as to drag the spinal cord against the odontoid process of the axis, by placing a small, firm pillow under the neck, while the patient lies flat on his back and extended in bed, the fulfilment of the second indication for treatment must next be attended to, which consists in moderating the inflammatory reaction at the injured joints, and preventing its spread to the spinal membranes and the spinal cord itself. Two examples have already been presented on the authority of Mr. Simon and M. Malgaigne, which go far to show that the spread, in such cases, of traumatic inflammation from the injured joints to the spinal meninges and the spinal marrow, is no idle dream. Among the best means to fulfil the second indication, is to keep the injured joints as nearly immovable as possible, by applying a bag half-filled with sand close to each side of the head and neck, continuously day and night, so as to entirely prevent any lateral or rotatory motion of the parts. The patient should be supplied with food and drink while in the supine position, and without raising his head. Not unfrequently the application of leeches and cold lotions may be advisable. This plan of treatment should be continued until the cure is complete. Potassium iodide may oftentimes be administered with advantage in order to promote the absorption of inflammatory effusions and of blood from the spinal canal. The diet should be nourishing and easy to assimilate. Pain should be subdued and sleep secured by administering opium or morphia.

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[1] Journal de Desault, t. iii.

[2] Journ. der Chirurgie, 1822, Bd. iii.

[3] Wien. med. Halle, 1864, S. 147; New Syd. Soc. Year-Book, 1864, p. 280.

[4] Hamilton, Princ. and Pract. of Surgery, p. 315.

[5] London Repository, vol. xv.

[6] Boston Medical and Surgical Journal, vol. x.

The condition of the back must be daily examined in order to forestall the occurrence of bed-sores. The parts must be kept dry and clean. Pressure must be removed from the salient points as far as possible, which can best be done by placing the patient on a water-bed. The condition of the bladder should be cared for from the outset. Retention of urine is almost certain to exist, for a time, and over-distension of the viscus is very detrimental. Catheterization should be performed with extreme care at least twice a day. If the urine become offensive, the bladder should be washed out daily with a weak solution of borax or boracic acid. The bowels should be moved by enemata rather than by purgatives. When incontinence of urine, or of feces, or of both, exists, the greatest attention must constantly be paid in order to keep the parts clean and dry. The frequent application of a spirit lotion, containing two per cent. of carbolic acid, to the parts, often proves useful.

In cases where the paralysis begins in the lower extremities, some hours after the accident, and steadily rises higher and higher, should the surgeon conclude the cause thereof to be the extravasation of blood (hemorrhage) occurring within the theca vertebralis, he might be justified in exhibiting the fluid extract of ergot, in full doses, and the acetate of lead and opium, as hæmostatics.

Unilateral Dislocations of the Cervical Vertebræ.—Hitherto, the symmetrical or bilateral luxations of the cervical vertebræ only have claimed our attention; but, now, the unilateral ones must be considered. They essentially consist in the displacement of the inferior articular process on one side of a cervical vertebra, from the corresponding superior articular process of the vertebra which lies next below; and they cause the victim's face to be turned toward the side opposite to that on which the luxation is situated. Many examples of this lesion have occurred, and a considerable number have been recorded. Twenty-nine cases are mentioned in Professor Ashhurst's tables. Desault related, in his lectures, the case of a lawyer, who produced this luxation, while sitting in his office with his back to the door, by turning his head suddenly round to see who was coming in. Chopart showed a young man, aged 24, who sustained a similar lesion from turning his head too far round; his face was turned to the left, and his chin ever afterward rested upon the left shoulder. (Boyer.) The following is an excellent example in which the deformity was removed with success by reducing the luxation:—

Maxson, of Geneva, N. Y., relates the case of a young girl, aged about 9 years, who had a dislocation of the right oblique process of the fifth or sixth cervical vertebra, caused by turning her head suddenly round while at play. At first, she complained only of inability to straighten the neck, and she became faint whenever she was moved. About forty-eight hours after the accident, her mother attempted to turn her head slightly, and a severe convulsion ensued. Soon after that, Dr. Maxson saw her, and could distinctly feel the displacement of the transverse process. He grasped her head with both hands, and turned it gently in the same direction as that to which it was already inclined, namely, toward the left shoulder, in order if possible to disengage the process; then lifting or extending the head, he carefully rotated it in the opposite direction, that is, toward the right side, and the reduction was accomplished. Her recovery was speedy and complete.[1]

Etiology.—In 23 of the 29 examples of this lesion that are mentioned in Professor Ashhurst's tables, the mode of injury was as follows: Turning the head quickly round, 6 instances; falling on to the head, 9; a fall striking on the neck, 2; a bundle slipped on the shoulder, 2; a fall in running, 1; direct violence, 1; being thrown against a wall, 1; tumbling heels over head on a bed, by a boy 8 or 9 years old, 1. In 6 cases the mode of injury is not stated. Thus, it appears that unilateral luxation of the cervical vertebræ is often caused, directly, by voluntary action of the muscles in turning the head suddenly to one side, as well as by blows and falls upon the neck itself; and that it also is often caused, indirectly, by falling upon the head, and by other forms of external violence, especially if they produce both rotation of the head and inclination of it to one side, as well as flexion.

Symptoms and Course.—The phenomena and consequences of this lesion may be best described by briefly presenting another example:—

M. Parisot[2] was called to a woman, aged 59, who had fallen from a load of hay, and found her condition as follows, thirty-six hours after the accident: The face was inclined to the right, and her chin rested a little external to the sterno-clavicular articulation of that side. The cervical region was concave on the right side, the heads of the sterno-cleido-mastoid muscle being relaxed; on the left side it was convex, and the lateral muscles were tense. The spinous processes could be felt, but without any projection. The head and neck were fixed immovably, and any attempt at motion caused great pain. The patient could not raise her head at all. Her face was congested, and the jugular veins were turgid; there was slight exophthalmos, and her respiration was becoming difficult. The right arm was paralyzed as to motion, and its sensibility was obtuse; there were also "pins and needles," and cold sensations at the ends of the fingers. The left arm was freely moved, but "pins and needles" were likewise felt therein. All the symptoms were aggravated by any attempt to raise the head. The position of the head had been unchanged since the accident; but the subjective symptoms had come on gradually, and were increasing. There was no loss of innervation in the lower part of the body. The diagnosis was unilateral dislocation of the fifth from the sixth cervical vertebra, on the right side.

The patient was placed sitting on the floor; the shoulders and legs fixed; the operator, standing behind, seized the lower jaw with both hands, the thumbs abutting on the mastoid processes, and raised the head gradually, then turned it briskly inward. A crack was heard; the patient immediately experienced great relief, and tried to turn her head around, but the paralysis had not disappeared. She was placed in bed, with her head extended by means of a weight of two kilogrammes [about 4½ lbs.] suspended from a band fastened around the jaw; leeches and cold lotions were also applied. Next day, the paralysis of the arm had disappeared; in seventeen days, the pricking sensations were gone, and the patient recovered.

This case, take it all in all, is a not unfair representative of a rather numerous class of cases, in which unilateral dislocations of the cervical vertebræ have occurred. The stiffness, soreness, pain, and immobility of the neck, with the face turned away from the dislocated side, the peculiar distortion exhibited by the neck itself, the paralysis of one upper extremity, attended with other symptoms of nervous disorder, more dangerous in character and constantly increasing in severity, all of which were promptly relieved by restoring the luxated vertebra to its normal position, are phenomena that have been observed in many other instances of this lesion that have been recorded. In several cases, too, dysphagia has been present; and, in one instance, the dislocated vertebra was found to cause a projection into the pharynx. In another case, paralysis of the upper extremities, convulsions, and hiccough were present, but they disappeared on reducing the dislocation, and recovery ensued. In but one instance is it stated that there was no weakness of the limbs. More or less paralysis, however, was noted in almost all the examples of this lesion which are mentioned in Professor Ashhurst's tables. While, in some of them, the paralysis was but slight, or quite limited in extent, and did not appear until some hours after the accident, in others, it was extensive, appeared instantly, and increased rapidly, so that death ensued in a few hours if reduction was not effected; in one case, where paralysis with dysphagia instantly appeared, death ensued in six hours, and, on dissection, incomplete unilateral dislocation of a cervical vertebra was found; in another case, where the accident instantly caused paralysis, death ensued in thirty-six hours under expectant treatment, and, on autopsy, unilateral dislocation of a cervical vertebra was found; in still another case, where death ensued in thirty-six hours, beside the dislocation, serous effusion on the arachnoid was found. In a case where paralysis, with congestion of the neck and face, was noted, death ensued in fifty-seven hours, and unilateral dislocation of the fifth from the sixth cervical vertebra was found, with rupture of the intervertebral cartilage, and compression of the spinal cord by the displaced bone.

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[1] Hamilton, op. cit., p. 315.

[2] Gaz. Hebd., 24 Nov. 1865; New Syd. Soc. Bienn. Retrospect, 1865–66, p. 283.

Diagnosis.—The recognition of unilateral luxations of the cervical vertebræ, when complete, is generally not difficult; certainly it is much less difficult than that of bilateral or symmetrical dislocations of these bones. The symptoms which characterize this lesion are the twisting of the neck, and the fixed position of the face turned more or less completely round toward the opposite shoulder, perceptible immediately after the accident; the immobility, with the abnormal lateral curvature, of the neck itself; the abnormal position of the transverse process belonging to the luxated side of the misplaced vertebra; and the tenseness of the muscles on one side of the neck combined with relaxation of those on its other side. Besides, the functions of the spinal cord or spinal nerves are, in general, more or less disturbed by the displaced bone, and, consequently, there is oftentimes observed in such cases paralysis of one or both of the upper extremities, with dysphagia, and sometimes also paralysis of the lower extremities, or paraplegia.

Prognosis.—The probability of a favorable issue is usually much greater in a case of unilateral dislocation of a cervical vertebra than it is in a case of bilateral dislocation of the same vertebra; for, in the former instance, the spinal cord usually sustains much less injury than in the latter. Moreover, unilateral dislocation of these bones is complicated with fracture much less frequently than bilateral or symmetrical dislocation. At all events, the statistics show that the prognosis is much more favorable if only one of the articular processes of a cervical vertebra be luxated, than it is when both are displaced. For example, among the twenty-nine cases of unilateral dislocation which are mentioned in Professor Ashhurst's tables, there were twenty-one recoveries and only eight deaths. Furthermore, it is very instructive to note that, of the twenty-one recoveries, fifteen appear to have been achieved by reducing the dislocation, and four without attempting to reduce it, while in two instances the treatment is not stated; and that, among the eight deaths, there was only one case in which reduction was employed, and that in this case the autopsy showed that the dislocation had been reproduced.

The symptoms of peculiarly evil import are, a steady increase of the area in which paralysis is noted, dysphagia, the advent of difficult breathing, with turgescence of the veins of the neck and face, and the appearance of exophthalmos from impending suffocation. In such cases, if the spinal cord be not promptly relieved from pressure by reducing the dislocation—that is, if the cause of the morbid phenomena be not promptly removed—death will speedily ensue. In some cases, however, death does not occur until the lapse of many days. In at least one instance on record, the paralysis came on gradually, and death ensued in twelve days. In another instance, the paralysis did not begin until several hours after the accident, but it gradually increased, and death ensued in forty days.

Treatment.—The first indication in the treatment of unilateral luxations of the cervical vertebræ, no doubt, is to reduce the luxation. In no case can the deformity resulting from the luxation be removed, unless this indication be first fulfilled; and, in most cases, recovery from this accident cannot take place, unless the dislocated bone be seasonably restored to its normal position. As already intimated, reduction was employed in sixteen of the twenty-nine cases of this lesion, mentioned in Professor Ashhurst's tables, and it proved successful in all but one of the sixteen; in the solitary instance of failure, an autopsy showed that the dislocation had been reproduced. In no one of the eight fatal cases was a reduction of the dislocation permanently effected.

Moreover, the paralysis was *instantly* removed by reduction in many of the successful cases. The motions of the head and neck, too, were instantly restored by reduction in several of them. Likewise, the accomplishment of reduction was attended by an audible sound in several instances.

Concerning the method by which extension and rotation are to be applied in order to reduce the dislocation, Mr. Erichsen says: "In these cases I have known reduction effected by the surgeon placing his knees against the patient's shoulders, drawing on the head, and then turning it into position, the return being attended by a distinct snap."[1] For other methods of applying extension, etc., in these cases, the reader is referred to the examples of the accident, already presented.

To prevent a recurrence of the dislocation, it may be advisable to apply a collar of stiff pasteboard to the neck, for eight or ten days, as practised by Malgaigne and others; or to make permanent extension by means of a weight of two or three pounds attached to the head by means of a band and strips of adhesive plaster, as practised by M. Parisot.

To avert inflammation of the injured vertebral joints, spinal membranes, and spinal cord, rest upon the back in bed, with a small firm pillow placed under the neck, and a half-filled bag of sand fitted to each side of the head and neck to prevent any lateral movement thereof, are always necessary. Not unfrequently, leeches and cold compresses should also be applied to the injured part. The risks arising from consecutive inflammation are well illustrated by Dr. Reyburn's case of unilateral dislocation of the fifth cervical vertebra, in which, though reduction was effected, death, caused by abscess of the spinal cord, followed fourteen days subsequently.[2] Pain should be moved and sleep procured by giving morphia or opium.

Boyer rejected all efforts to reduce the dislocation in these cases, and quoted Petit-Radel's celebrated case to illustrate the danger of such efforts. But, as Malgaigne has shown, the case of Petit-Radel was not at all such as represented by Boyer; and the fact that in his case the efforts at reduction caused sudden death, proved nothing but that the efforts were unskilfully made by an incompetent person. (Ashhurst.) In that case the transverse ligament of the atlas was ruptured by the efforts at reduction, and the spinal cord was pressed forward against the odontoid process of the axis, with an instantly fatal result.

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[1] Op. cit., p. 293.

[2] Am. Journ. of the Med. Sciences, July, 1871, p. 110.

The various kinds of cervical dislocation enumerated above are of great importance: (1) Because they constitute the sole lesions in about one-half of all the cases of vertebral injury which occur in civil life; (2) Because they are very deadly and often end very quickly; and (3) Because there is ground for hope that with improved methods of treatment their fatality may be considerably diminished.

DISLOCATIONS IN THE DORSAL AND LUMBAR REGIONS.—Dislocations of the vertebræ unattended by fracture are comparatively rare in the dorsal and lumbar regions. To illustrate this point, I will again state that, in 394 cases of spinal injury collected by Professor Ashhurst, only 17 examples of pure dislocation are reported as having occurred in the dorsal region, and but 3 in the lumbar region, while 104 cases of uncomplicated dislocation are credited to the cervical region. Again, of 56 fatal cases of spinal fracture and dislocation observed at Guy's Hospital, in which there were autopsies, 36 occurred in the cervical region (11 thereof being examples of pure dislocation, and the remaining 25 being instances of dislocation combined with fracture), 18 occurred in the dorsal region, and 2 in the lumbar (Bryant); but only two or three of the dorsal and lumbar cases, at the utmost, were examples of pure dislocation. The comparatively great infrequency of pure dislocations in the dorsal and lumbar regions is explicable: (1) by the fact that in traumatic spinal lesions of all sorts the cervical region is affected much oftener than both the other regions combined; and (2) by the way in which the articular processes of the dorsal and lumbar vertebræ are locked together, and by the extreme obliquity of the dorsal spinous processes, the consequence whereof is, as a rule, that at least some one or more of them is broken when a dislocation occurs in these regions. Luxations unattended by fracture are, therefore, quite exceptional in the dorsal and lumbar spine.

Etiology.—Dislocations of the dorsal and lumbar vertebræ are always due, directly or indirectly, to the application of external force; muscular action is never their chief cause. They are often produced by heavy falls from high places upon the back, shoulders, or buttocks; and, in such cases, the dislocation is, in the first-mentioned instance, directly, and, in the last two instances, indirectly occasioned, as a rule. Dorsal and lumbar dislocations, too, are not unfrequently caused, directly, by heavy blows upon the back and loins. For example, in 20 cases of dorsal or lumbar dislocation collected by myself, the lesion was caused by falling from high places, *e.g.*, from trees, from the windows and upper floors of houses, etc., in 8 instances; by falling down fourteen or fifteen steps in 1 instance; and, by falling upon the buttocks in 1 instance. Also, the lesion was caused by a blow on the back from a ton-weight, in 1 instance; by being struck on the back by a falling door, in 1 instance; by the fall of a scaffold-pole, in 1 instance; by being struck by falling timber on the shoulders, in 1 instance, and on the loins, in 1 instance; by the running of a carriage-wheel against the back, in 1 instance; by being struck on the back by a falling wall, in 1 instance; by the fall of a mass of chalk, in 1 instance; and, by striking the back against a beam in driving through an archway, in 2 instances. In each of the 10 cases, first mentioned, the luxation was caused by a heavy fall; and, in each of the remaining 10 cases, it was produced by a heavy blow on the back.

To illustrate dorsal luxation, the following case is in point:—

A man,[1] from falling down through five hatchways, received a dislocation of the sixth from the seventh dorsal vertebra, and was brought to the Brooklyn City Hospital. "No other injury was sustained. He presents all the symptoms of this lamentable accident, but has now been lying upon a water-bed for ninety days, and, to all appearances, is in a far better condition than he was one month ago. The patient is kept partly under the influence of morphia."

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[1] Medical Record, p. 145, vol. ix. 1874.

The following example, from being more fully reported, is much more instructive: A man, aged 21,[1] fell from a chestnut tree, October 4, 1871, a distance of some twenty-five or thirty feet, striking the ground with his shoulders and back. When picked up he was insensible. On recovering consciousness, he complained of severe pain in the back, shooting round into the hypogastrium and left groin. About two hours after the accident, Dr. Simpson found him lying partially on his right side, with knees drawn up and almost immovable. His back was slightly bruised and scratched, and presented a deformity indicating apparently a displacement forward of the vertebræ at the lumbo-dorsal junction; sensation in lower extremities diminished, but not obliterated; intense pain in back and in abdomen. Cold applications to the patient's back were ordered, and that he should be kept as quiet as possible; forty drops of liq. opii comp. every two hours, during the night. Next morning, Dr. Hasbrouck saw the patient in consultation. He recognized the partial dislocation of the last dorsal vertebra, but doubted the propriety of attempting to reduce it. He suggested, however, that potassium iodide, grs. v, repeated every four hours, should be added to the treatment.

Urine was passed by the patient without assistance on the night succeeding the injury. After that, catheterization had to be practised twice daily, for the next ten days, when voluntary micturition, with some straining, was re-established. There was constipation, which was not relieved by enemata, nor by purgatives *per orem*, until a hardened mass of feces in the rectum had been broken down by a finger introduced for the purpose. After twelve days, the bowels became regular. All the symptoms now began to improve regularly, excepting the deformity of the back, which increased much in extent. In about three weeks after the accident, the patient began to sit up in bed; and, four or five weeks later, to walk around the house, with the aid of a cane. During the fall and early winter, his back continued quite weak. In January, 1872, he had a brace fitted for the support of his back. March 26, 1872, he commenced work again at his trade, that of a mason. With the artificial support furnished by the brace, he feels as well, he says, as he did before the accident.

These two cases illustrate very well, not only the etiology and symptomatology of dorsal luxations, but likewise some important points in the treatment of these lesions. The patient first mentioned, derived much benefit from the water-bed upon which he had been lying for three months, when his case was reported, and from the prolonged use of enough morphia to keep him free from all pain, and to procure for him sufficient sleep. Opium administered in this way, to such patients, generally exerts a happy influence in preventing the occurrence of inflammatory complications in the spinal membranes and spinal cord, as well as in sustaining the patient's strength.

In the case last mentioned, the lesion, that is, the luxation forward of the twelfth dorsal upon the first lumbar vertebra, was caused, indirectly, by falling from a great height upon the shoulders and back. There was, for a time, insensibility from cerebral concussion. The forward displacement of the twelfth dorsal vertebra was cognizable by inspection and by manual examination; and there was incomplete paralysis of the parts below the spinal lesion. The symptoms and consequences of a vertebral dislocation were therefore clearly present; but great pain in the injured portion of the spinal column, and in the parts of the abdomen to which the spinal nerves involved in the lesion were distributed, was also observed. It was subdued by administering the opium solution in large doses and at short intervals (gtt. xl every two hours). Opium or morphia, when exhibited in full doses, is one of the most efficient agents we possess for allaying inflammatory excitement, especially in fibrous and serous membranes. Cold applications to the injured parts of the back were made, and absolute quietude was enjoined. Besides the opium, potassium iodide, 5 grains every four hours, was given internally. Thus, it will be perceived, that strong measures were adopted from the outset to allay any inflammation of the spinal membranes or the spinal cord which might threaten to follow the injury. To these antiphlogistic measures I attribute most of the success which was obtained in the treatment of this case. The non-employment of extension and counter-extension was evidently a mistake; for, had they been continuously applied for two or three weeks, the displacement of bone would not have increased, as actually happened, and the bladder would not have become paralyzed on the day after the accident. The excellent results which were obtained, in this case, by obviating the tendency to inflammation in the bruised and strained spinal membranes and spinal cord, by employing appropriate treatment internally as well as externally, should teach us to do likewise in all similar cases. That there is a real need for so doing, in such cases, the following observations will prove:—

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[1] American Journal of the Medical Sciences, April, 1873, pp. 502, 503.

A man, aged 40, was admitted to the Saint André Hospital, at Bordeaux,[1] with severe injury of the back. Mobility of the eleventh dorsal spinous process was detected. Temporary loss of consciousness from shock occurred. Then severe pain in the seat of the injury, which was near the origin of the eleventh dorsal nerves, was complained of. The parts supplied by the sacral and lumbar plexuses of nerves were paralyzed, and voluntary motion of the lower extremities was abolished. Anæsthesia of the lower extremities, and of the abdominal wall as high as the umbilicus, existed, with exaggerated reflex motility in the lower extremities. There was priapism, with retention of urine and feces, and tympanites, from vesical and intestinal paralysis. The pulse rose to 112; the breathing became diaphragmatic and difficult; and, on the eleventh day, death occurred. *Dissection* revealed fracture of the laminæ of the eleventh dorsal vertebra, with dislocation of its body in front of the twelfth, contusion of the cord, and ascending myelitis. Here, then, a contusion of the spinal cord arising from a dislocation with fracture of the spinal column, eventuated in a traumatic inflammation of the spinal cord, which caused death by spreading upward until it involved the roots of the phrenic nerves, and thus suppressed the respiratory movements; and the fatal issue of this case could have been prevented, only by averting the consecutive inflammation of the spinal cord.

Bryant[2] reports the case of a laborer, aged 33, injured by timber falling on his shoulders. At first, there was loss of sensation, but not of motion; afterward, loss of motion, but return of sensation; finally, loss of both. In ten days death ensued. Dislocation forward of the eleventh dorsal vertebra, with fracture of the twelfth, was found; and the spinal cord was disorganized. (Ashhurst.) In cases such as this, the disorganization of the spinal cord which directly precedes, and is the proximate cause of death, is always due to inflammatory action; and well directed efforts to subdue it should always be made, by appropriate treatment, both general and local.

Robert[3] mentions the case of a laborer, aged 25, who was injured in the back by a scaffold-pole falling on him. There was paralysis (paraplegia), etc., noted, but no deformity. In eleven days, however, he died. Dislocation of the fifth from the sixth dorsal vertebra was found; and the spinal cord was diffluent. This case clearly belongs to the same category as the last two, and in it an ascending myelitis of a destructive character also resulted from the injury, and caused death.

Charles Bell[4] relates the case of a coal-wagoner, thrown from his cart while drunk, striking upon his neck and shoulders. He complained of a stiff neck, could not stand alone, and dragged his legs when supported; but when lying in bed, no paralysis appeared. Between the shoulders, at the root of the neck, there was swelling and ecchymosis; and in the loins acute pain. Leeches were applied to the swelling. On the eighth day convulsions occurred, and were followed by mania. On the eleventh day paralysis appeared, which afterward began to pass away. On the twentieth day death ensued. *Dissection* revealed diastasis of the seventh cervical from the first dorsal vertebra; the intervertebral cartilage had disappeared from suppurative inflammation, and purulent matter had dropped to the bottom of the spinal sheath (theca vertebralis). Outside of the injured vertebræ a large abscess was found. In this case the vertebral lesion had given rise to a destructive inflammation of the intervertebral cartilage and the formation of much pus, together with a suppurative inflammation of the spinal meninges; the latter condition, unless arrested by timely treatment, necessarily proves fatal.

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[1] Pousson et Lalesque, Revue Mensuelle, Juillet, 1880; Lond. Med. Record, Jan. 15, 1881.

[2] Guy's Hospital Reports, 3d S., vol. v.

[3] Half-Yearly Abstract of Med. Science, 1854.

[4] Surg. Observations, Part ii., p. 145.

Charles Bell[1] reports the case of a plasterer, aged 25, who fell forty feet, striking his back against a stone step. Depression between the spinous processes of the lower dorsal vertebræ was observed, but no paralysis. He had acute pain in the back. On the third day he was delirious, threw himself out of bed, etc. On the fifth day he had to be tied in bed, and, on the same day, he died. *Dissection* showed fracture of the body and spinous process of the eleventh dorsal vertebra; the spinal cord was not compressed by the fracture; but greenish pus was found between the cord and the theca vertebralis, and there was effusion on the brain. (Ashhurst.) From the vertebral fracture there evidently arose in this case traumatic cerebro-spinal meningitis, of a suppurative character, which caused death. It is not probable that this inflammation could have been successfully combated without the aid of local blood-letting by leeches or cups, and the continuous application of an ice-bag or an iced poultice, with opium and morphia in large doses, and potassium iodide, as well as absolute quietude of the injured and inflamed parts.

Dupuytren[2] mentions a case which, during life, was supposed to be concussion of the spinal cord only; there was partial paralysis and sloughing; but, in the end, death ensued. *Dissection* revealed fracture of the tenth dorsal vertebra; blood-clots and meningitis opposite the ninth, tenth, and eleventh dorsal vertebræ. (Ashhurst.) Besides the spinal fracture and the spinal meningitis, the autopsy in this case revealed an effusion of blood between the cord and theca vertebralis. Such hemorrhages are frequent concomitants of the vertebral fractures and dislocations that occur in the dorsal and lumbar regions, as well as in those that occur in the cervical region.

Dr. C. A. Lee[3] reports the case of a man, aged 48, injured by falling from a building across a plank. At first, he was stunned; and, afterward, very restless. On the next day paralysis appeared; and a projection in the middle of the back was noted. In five weeks death ensued. *Dissection* showed fracture of two dorsal vertebræ; the spinal cord was softened; and purulent matter was found in the vertebral canal. Here, too, spinal meningitis arose from fracture of the dorsal vertebræ, and was attended by the formation of pus. Obviously, such cases cannot be conducted to a successful issue, unless the occurrence of traumatic spinal meningitis in them be seasonably recognized, and the disorder itself combated by appropriate treatment.

Many additional examples of spinal meningitis and myelitis arising from spinal dislocations and fractures might be cited from the records. But, enough of them already have been presented to clearly show that, in every case of vertebral dislocation or fracture, where life continues, there exists a strong tendency for consecutive inflammation of the spinal membranes and cord to ensue; that, not unfrequently, traumatic meningitis or myelitis is the proximate cause of death, in such cases; and that the surgeon should, in all such cases, employ remedial measures of known efficacy, from the outset, in order to prevent the traumatic irritation of the spinal membranes and cord from rising to the grade of inflammatory action.

Symptoms and Prognosis.—When dislocation of the joints of a vertebra occurs in the dorsal or lumbar region, it is always attended by functional

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[1] Ibid., p. 138.

[2] Diseases and Injuries of Bones. London, Sydenham Society, 1847.

[3] American Journ. Med. Sciences, O. S. vol. xvii.

disturbance and displacement of the bones which form the compound articulation; and, generally, by ecchymosis. Inasmuch as the vertebral joints are more superficial in the dorsal and lumbar regions than they are in the cervical, the displacement of bone is more easily recognized by sight and touch in the former regions than it is in the latter. The symptoms by which luxations of the dorsal and lumbar vertebræ may be known, are the deformity and the disturbances of function which arise from the displacement of the luxated bones, and the ecchymosis. The displacement is often denoted by a projection backward of the lower vertebra. Sometimes a distinct gap can be felt between the dislocated vertebra and the bone next below it. Frequently their spinous processes are found to be separated by a considerable interval. Occasionally they are so widely separated that three fingers can be laid between them. Oftentimes the patient has severe pain in the injured part of the back. Not unfrequently the patient has also severe pain in parts far removed from the back, that is, in the parts where the spinal nerves that pass through the inter-vertebral notches at the place of injury, are distributed or have their terminal extremities. Should the spinal cord be much injured, there will be paralysis both sensory and motor (paraplegia) of all the parts supplied by spinal nerves that issue from the segment of the cord which lies below the lesion. Paralysis of the bladder will be denoted by retention or by incontinence of urine; paralysis of the intestines by retention or by incontinence of feces, and by tympanites. The area of lost sensibility usually corresponds very closely to that of the motor paralysis, because the anterior and posterior roots of the spinal nerves emerge from the cord on the same level. The following example will serve to show how profound and durable the sensory paralysis, as well as the motor, may be:—

Dr. W. D. Purple[1] reports the case of a man, aged 22, injured from being struck by the limb of a tree. There was dislocation of the fifth and sixth dorsal vertebræ with permanent as well as complete paralysis, both sensory and motor, of the lower part of the body, or paraplegia. Six years afterward he had both thighs amputated high up, because the paralyzed limbs were useless appendages. He felt nothing whatever during the operation, although no anæsthetic was employed. Seven years after the injury he died from other causes; no autopsy.

But, in many cases of vertebral dislocation or fracture with injury of the cord, marked *hyperæsthesia* with *intense pain* is noted *just above* the paralyzed region.[2] The last-named symptoms, however, will be discussed in connection with the subject of *Traumatic Myelitis*, as it is the disorder from which they arise.

Should the ganglionic nerves which lie along the spinal column, on each side thereof, and in close relation thereto, be much injured, especially in the cervical region, there may arise therefrom, as well as from injuries of the spinal cord, vaso-motor disturbances, denoted by alterations of the pulse, by flushing of the face, and by a considerable increase or diminution of the body-heat. Paralysis of the vaso-motor nerves, thus induced, lessens the blood-pressure in the arteries, and modifies the character of the pulse accordingly. With each blood-wave, the condition of feeble pressure passes suddenly into a condition of forcible pressure at the moment of the ventricular systole, and suddenly reverts to the former condition, for the blood flows too readily through the paralyzed capillaries from the arterial into the venous system. MM. Pousson and Lalesque found this forcible impulse or peculiar sensation of a strong pulse to be most marked in large arteries, *e. g.*, the femoral and the abdominal aorta. The sphygmographic tracing presents, with pulse-modifications of this kind, a very high and vertically ascending line, and a concave and prolonged descending line.[1]

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[1] New York Journal of Med., 1853.

[2] Med. News and Abstract, March, 1881, pp. 179, 180.

In regard to changes of the body-heat in consequence of spinal injuries, I will briefly mention a few examples:—

Dr. T. G. Morton[2] found in a case where the fifth, sixth, and seventh cervical vertebræ were fractured, with paralysis, etc., that the temperature two hours after the accident was 102° Fahr; in eleven days the patient died. Professor William Pepper[3] relates a case in which there were fractures of the first and fourth cervical vertebræ, with anterior luxation of the latter, as well as compression of the spinal cord, death ensuing 24½ hours after the injury; the whole cutaneous surface was much warmer than normal, and a thermometer in the axilla registered 108.5° Fahr. at the moment of death; the cheeks were brightly flushed, and very hot; but the pupils were about normal. Mr. Shaw[4] relates the case of a drayman, aged 35, injured by a bag of hops falling upon his head and shoulders, in which there were fracture of the fourth dorsal vertebra, paralysis, priapism, and a temperature of 103–106° Fahr. (Ashhurst.) Brodie's case of spinal injury, in which the mercury rose to 111° Fahr., has already been mentioned. A number of cases are on record in which "calor mordicans" was noted. On the other hand, Dr. A. Nieden[5] reports the case of a man, aged 60, injured by falling down fourteen or fifteen steps, in which there were temporary loss of consciousness, complete paralysis of lower extremities, bladder, and greater part of trunk, progressive lowering of the temperature, and pulse of a remarkable character. He died on the eleventh day after the accident, with a temperature of 80.6° Fahr. He remained conscious until his temperature was 81° Fahr. and his pulse 30. The *autopsy* showed luxation without fracture of the first dorsal vertebra, with compression of the spinal cord. A somewhat similar case was under the care of Mr. Hutchinson, at the London Hospital. There was complete paralysis as high as an inch above the nipples, with marked priapism; temperature 98°. The next day the pulse was noted at 36 and small; in the evening, the temperature in the rectum was only 95.8°, in the distended penis 93°. The patient's cheeks and lips were of very good color, remarkably so; while to the touch they seemed as cold as those of a corpse. But he did not complain of feeling cold. The temperature sank to 95°, and, on the sixth day, he died. The temperature did not rise after death. The autopsy showed fracture of the fifth cervical vertebra, and severe injury of the cord.[6] Something like a "flushed face" appears to have been noted in this case, although the temperature was much below the normal.

No clear explanation of cases such as this has yet been made. But paralysis of the vaso-motor nerves may arise from lesions of the spinal cord, as well as from injuries of the ganglionic chain of nerves, or the great sympathetic. "Flushing of the face," in cases of spinal injury, is usually attended by lachrymation and contracted pupils, and is clearly due to vaso-motor paralysis.

Mr. Erichsen says that he has seen unequivocal instances of continued low temperature of the body, taken in the mouth and axilla, in cases of spinal concussion—as low as 92° or 93° F., and continuing for many months from 2° to 3° F. below the normal.[7] He also refers to Dr. Nieden's case in which the first dorsal vertebra was dislocated, mentioned above. "More commonly the low temperature is confined to the extremities, especially the feet, which are sensibly colder than other parts of the body. Often the feet are as low as 80° to 85° F., and will remain so for very long periods of time."[8]

The *prognosis* in cases where the dorsal or lumbar vertebræ are injured is usually much less unfavorable than it is in cases where the cervical vertebræ have sustained similar lesions; and, as a rule, the further the seat of injury is removed from the respiratory centres, the more favorable is the prognosis. In dorsal and lumbar dislocations and fractures, without intra-spinal hemorrhage, the chief sources of danger to life are the occurrence of spinal meningitis, of ascending myelitis, of trophic lesions such as sacral and gluteal eschars or bed-sores, and of vesical or renal inflammation. The appearance of either of these complications greatly increases the gravity of every case. There are some symptoms, however, which are especially bad prognostics. Among them may be mentioned persistent elevation or depression of the body-temperature, flushing of the face, great frequency or infrequency of the pulse, early appearing and rapidly spreading sacral or gluteal eschars or acute bed-sores, incontinence of urine and feces succeeding retention, enlargement of the paralyzed area in an upward direction and increase of the paralytic symptoms, especially when they are progressive, diaphragmatic breathing, and dyspnœa. Incontinence of feces and urine succeeds retention in these cases, because the sphincter muscles have become paralyzed; and this circumstance denotes that the nerve centres upon which their action depends have become affected. Progressive, upward extension and deepening of the paralysis, generally indicate progressive, upward disorganization of the cord. Diaphragmatic breathing coming on some days after the accident, is a most unfavorable symptom, and generally denotes that the compression or disorganization of the spinal cord has attained so high a point that the diaphragm alone of all the respiratory muscles remains unparalyzed. Dyspnœa occurring in this connection usually indicates that the aëration of the blood is quite imperfect, and that the induction of fatal coma in consequence thereof may be at hand. Priapism is generally a dangerous symptom, but not necessarily a fatal one; for there are cases on record of recovery from spinal injury where this symptom had existed.

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[1] Ibid., p. 181.

[2] Proceedings of the Pathological Soc. of Philadelphia, vol. i.

[3] American Journal Med. Sciences, April, 1867, pp. 437, 438.

[4] Holmes's System of Surgery, vol. ii.

[5] Clin. Soc. Trans., vol. vi. 1873.

[6] New Syd. Soc. Retrospect, 1873–4, pp. 351, 352.

[7] On Concussion of the Spine, etc., 1882, p. 65.

[8] Ibid.

The progressive diminution of paralysis, in these cases, is a most favorable symptom. The return of motor power is not unfrequently attended by involuntary contractions and twitchings of the muscles; these symptoms, however, are not to be considered unfavorable at this stage, although they are supposed by Brodie, and probably with justice, to indicate compression or mechanical irritation of the spinal cord when they attend an earlier stage.

Treatment.—In no case of dislocation of the dorsal or lumbar vertebræ, however clear the symptoms of the dislocation may be, can it be asserted with absolute certainty during life that no fracture is present. While pure dislocations of these vertebræ are quite rare, dislocations combined with fracture are quite common in the dorsal and lumbar regions; but the treatment of both forms of injury should be conducted on substantially the same plan. The want of a strictly exact diagnosis in this regard is, therefore, not as essential to the therapeusis of dorsal and lumbar dislocations as it is in those of the cervical region.

The condition of the injured parts in dorsal and lumbar dislocations, as well as in cervical, is usually as follows: The muscular and connective tissue around the displacement is extensively lacerated and infiltrated with blood; the intervertebral disk or ligament is torn through at the seat of displacement, so as to allow the body of the upper vertebra to be thrown forward from that of the lower; the anterior and posterior common ligaments are much stretched and extensively detached; the ligamenta subflava and the capsular ligaments are lacerated; the laminæ, or certain of the vertebral processes, are fractured; the theca vertebralis is stained with blood, bruised, stretched, and perhaps somewhat torn; the spinal canal contains more or less blood; while the spinal cord is ecchymosed and abruptly bent, and sometimes presents a compressed appearance, or is even divided completely, at a point corresponding to the displacement of the vertebræ.

The victim of this accident should be taken up from the place where he has fallen, and removed to hospital or home with great care to avoid increasing the displacement of the luxated bone and the injury of the spinal cord, as already described for cases of cervical dislocation. The patient should be placed in bed; and then, for reasons already stated under the head of treatment of cervical dislocations, which, however, are equally applicable in cases of dorsal or lumbar dislocation, the replacement of the luxated bone into its normal position should be attempted. But before proceeding further with the discussion, I will briefly describe the various methods which have been successfully employed, in practice, for accomplishing this result in the dorsal and lumbar regions; and, probably, I cannot do it in a better way than by presenting abstracts of the cases themselves.

Malgaigne[1] mentions a case of Melchiori's, in which a carter was injured in the dorsal region by a wheel running against him. There was backward dislocation of the eighth dorsal vertebra, and paralysis. Reduction was effected by position in bed. Recovery ensued in six months. Slight deformity, however, remained. (Ashhurst.) When it is found that, by placing the patient upon his back in bed, the displaced vertebra is restored to its normal position, with the aid, perhaps, of moderate extension and some pressure laterally applied, a good hair mattress or a water-bed (the latter is much preferable) should be arranged for his reception, and he must be kept lying upon it, as nearly immovable as possible, until firm union has taken place.

Rudiger[2] is credited with the case of a musketeer, who was struck on the back by a falling wall, and sustained dislocation backward and to the right side of the twelfth dorsal vertebra. Reduction was effected by position (on the belly) in bed; extension and pressure were continued for fifteen days. In six weeks recovery ensued. (Ashhurst.) This case shows that the surgeon, by consulting his ingenuity, may sometimes, perhaps not unfrequently, make the patient's posture in bed materially assist in reducing a vertebral dislocation of the back or loins, when the dorsal decubitus utterly fails to do it. Moreover, while the patient lies with the back uppermost, a free opportunity is afforded for the efficient application of local treatment, to prevent the development of consecutive spinal meningitis and myelitis.

Parker[3] mentions the case of a man who was struck on the back by a falling door, and sustained dislocation of the last dorsal on the first lumbar vertebra, with slight fracture. There were paralysis, priapism, etc. Reduction was accomplished, with an audible sound, by making extension and counter-extension, under chloroform. After several months the patient recovered, and, when discharged, could walk with a cane. (Ashhurst.) It is important to note that, notwithstanding there was priapism in this case, recovery ensued. The dislocation was reduced by making extension and counter-extension, under chloroform. I think the best plan for the surgeon to pursue, on failing to reduce such a dislocation by the patient's position in bed, would generally be to relax the muscles completely by anæsthesia, and, then, to effect the reduction by means of extension and counter-extension steadily made by his assistants, with lateral pressure locally applied by himself.

Brodie[4] refers to the case of a man, injured by a mass of chalk falling upon him. The first lumbar vertebra projected backward over the last dorsal. The dislocation was reduced with some difficulty by Mr. Hardwicke. The reduction was attended by a "jerk or snap." The patient was relieved; but, after two or three years, partial paralysis still remained. (Ashhurst.) No doubt, in this case likewise, the reduction was accomplished by making extension and counter-extension.

Smith[5] mentions a case of Schmucker's, in which a soldier was injured by a wall falling on his back. He was stunned; there was displacement backward of the last dorsal and first lumbar vertebræ, and dyspnœa. The displacement was reduced by extension and pressure. In six weeks the man recovered. (Ashhurst.)

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[1] Traité des Fract. et des Luxat., t. ii.

[2] Desault, Journ. de Chir., t. iii.

[3] New York Journal of Med., 1852.

[4] Med.-Chir. Trans., vol. xx. p. 157.

[5] New York Journal of Med., 1852.

Crowfoot reports[1] the case of a coachman, aged 42, who in driving under an arch struck the back of his neck against a beam. There was displacement forward of the ninth dorsal vertebra, and of the tenth, backward, with paralysis. He was treated by continuous extension with success, and resumed his occupation in one year; slight deformity, however, remained. (Ashhurst.)

After reduction, should the displacement reappear, and particularly if the dislocated bone should manifest a disposition to slip out of place again, it will be advisable to make the extension continuous, which may be done in several different ways; but, probably, with the least amount of trouble, by raising the head of the bedstead upon blocks so as to make of the bed itself an inclined plane sloping downward to the foot, when, by attaching with a suitable band the upper part of the patient's body to the head of the bedstead, the desired result would be obtained. Continuous extension might also be advantageously employed in cases where attempts at immediate reduction had failed, with a reasonable hope that, under its influence aided by the patient's posture in bed, the luxated bone would be induced to slip into place again.

To sum up this branch of the treatment—the surgeon should seek to restore the displaced vertebra to its normal position by some one of, or, should the occasion require, by all the means of effecting reduction which have just been pointed out, that is, by arranging the patient's posture in bed, upon the back or upon the belly, according to the case; by making extension and counter-extension, under anæsthetics, with the help of skilled assistants; or by making continuous extension, which the surgeon can generally accomplish without skilled help.

Having fulfilled the first therapeutical indication, the surgeon must at once take care that the paralyzed bladder does not become over-filled with urine; for, should this occur, much harm would ensue. To this end, catheterization must be cautiously practised at least twice a day, with a soft instrument; and, at each time, the surgeon should cautiously compress the paralyzed bladder with his own hand, applied to the abdominal walls of the patient, in order to secure a complete evacuation of the viscus; for any urine that might be allowed to remain in it would, by undergoing decomposition, cause unnecessary mischief. Vesical and even renal inflammation may readily ensue in these cases. But this subject will be found to be more fully discussed under the head of Disorders of the Urinary Organs arising from Lesions of the Spinal Cord.

The surgeon must also take care that the patient is provided with such a bed as will least favor the occurrence of bed-sores; the best is a water-bed, the next best a good hair mattress. The surgeon must at every visit examine the private parts and buttocks of the patient, in order to see, for himself, that they are kept dry and clean, and are not inflamed, and that no gangrenous bleb nor eschar is forming. Motions of the bowels, when needed, should be procured by enemata rather than by purgatives. Immediately after a motion, the parts should be completely freed from feces by carefully wiping them, and then they should be cleansed by applying a spirit-lotion containing two per cent. of carbolic acid. This topic, however, will be more fully discussed under the head of Sacral Eschars and Acute Bed-Sores arising from Lesions of the Spinal Cord.

The occurrence of consecutive meningitis and myelitis must also be obviated as much as possible. I have already shown by a brief mention of seven examples, and by a reference to many others, that there exists, in every case of spinal dislocation or fracture, a more or less strong tendency for consecutive inflammation of the spinal membranes or spinal cord to ensue, and that in such cases the consecutive inflammation of the spinal membranes or spinal cord, by itself, not unfrequently causes death. Moreover, I shall presently show that consecutive inflammations of the spinal membranes and spinal cord, of this sort, always much increase the severity of the urinary symptoms and of the bed-sores which are met with in cases of vertebral dislocation and vertebral fracture, and that the prevention of these inflammations must be ranked among the most efficient means at our disposal for controlling these unhappy complications of spinal injury. Thus, one is enabled to perceive how important the fulfilment of the last-mentioned therapeutical indication really is.

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[1] Trans. Prov. Med. and Surg. Assoc., 1853.

Now, this indication is to be accomplished, that is, inflammation of the bruised and torn spinal meninges and spinal cord is to be obviated or controlled: (1) by reducing the vertebral displacement, as already directed; (2) by keeping the spinal column in a state of perfect rest, or as nearly immovable as possible, after the reduction has been effected; (3) should the patient's posture in bed permit, by drawing blood from the injured part by leeches or cups, and by applying dry cold, by means of an ice-bag, with compresses interposed, and, subsequently, by the employment of counter-irritants. But, whatever the patient's posture in bed, opium or morphia should be administered with sufficient freedom to allay pain and procure sleep, as already stated; and by keeping the patient somewhat under the influence of this drug until nature has repaired the breaches, much good can be done in the way of controlling any inflammatory action which may arise in the injured meninges; and, probably, in the spinal cord also. Potassium iodide, in doses of five grains every four hours, belladonna in full doses, and fluid extract of ergot, half a fluidrachm three times a day, will often prove to be very useful remedies for traumatic myelitis, as well as for traumatic spinal meningitis.

But, in attempting to reduce dislocations of the dorsal and lumbar vertebræ, is there not considerable danger that the spinal cord may be injured by the efforts of the surgeon himself? Many a person, doubtless, will be inclined to answer this question affirmatively, without much reason or reflection. Experience, however, has shown that this danger is more hypothetical than real. For example, reduction was effected in *fourteen* cases of displacement from injury of the dorsal or lumbar vertebræ, which are mentioned in Dr. Ashhurst's tables. In *eleven* instances the displacement occurred in the dorsal region; in *three* in the lumbar. *Seven* patients recovered, *two* were relieved, and *five* died. Of the cases in which the issue was successful I will not further speak; but the fatal ones I will briefly relate:—

(1) Higginson[1] is credited with the case of a man, aged 34, injured in the spine so that there was projection of the lumbar vertebræ one inch beyond the dorsal. Reduction was accomplished by making extension, under chloroform, with relief to the symptoms. In four weeks, however, he died; no account is given of the autopsy. (Ashhurst.) (2) Bryant[2] mentions the case of a laborer under Mr. Cock's care, aged 34, who fell from a scaffold across a wall. There were pain, paralysis, priapism, and deformity in the lower part of the spine. The last was removed by making extension and pressure. At the end of eight months death occurred. The *autopsy* showed dislocation forward of the eleventh dorsal vertebra and fracture of the twelfth; the cause of death is not stated. (Ashhurst.) (3) Holmes[3] relates the case of a young man, aged 19, struck on the loins by falling timber. The last dorsal vertebra was dislocated. It was reduced by extension, and the reduction was attended by an audible sound. No relief

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[1] British Medical Journal, 1862.

[2] Proc. Path. Soc. London, vol. viii.

[3] Ibid., vol. x.

ensued. Death occurred twenty-three days after the accident. The *autopsy* showed dislocation with slight fracture of the twelfth dorsal vertebra, fracture of the first lumbar vertebra, and secondary deposits in both knee-joints. (Ashhurst.) (4) Luke[1] refers to the case of a man having fracture of the seventh dorsal vertebra, with displacement, which was reduced by extension, the reduction being accompanied by an audible sound. Death from erysipelas occurred seven days after the injury. The spinal cord was found to be softened and disorganized; there was purulent matter. (Ashhurst.) (5) Birkett[2] relates the case of a man, aged 31, who fell into the hold of a ship, striking his back, and dislocating the lower part of the spinal column. The fascia was torn off from several dorsal spines, and there was paralysis, etc. Extension under chloroform gave no relief; it was followed by great pain. At the end of four and a half months death ensued. The *autopsy* showed displacement of the eleventh from the twelfth dorsal vertebra, with fracture of the articular processes; spinal cord disorganized; suppuration of the kidneys. (Ashhurst.)

In but one of these five cases can it be asserted with any plausibility that the efforts at reduction were themselves attended by any misadventure whatever. In the last case, the employment of extension did not relieve the symptoms, and was followed by severe pain. Still death did not occur until four and a half months afterward; and, whether the advent of the pain was merely a coincidence, or not, it is certain that the use of extension was not, *per se*, attended by any destructive lesion. In the other four examples, death was caused by erysipelas, by septicæmia, and, probably, by myelitis.

Moreover, three cases of vertebral fracture with considerable displacement are related by Professor König, of Göttingen, in the Centralblatt für Chirurgie, No. 7, 1880, in each of which the deformity was corrected by suspending the patient, without any bad effect; and, in No. 46 of the same journal, we find a paper by Dr. W. Wagner that tells of two similar cases. All five patients recovered.[3]

Thus, we perceive, that the experience recorded on this point is already rather voluminous, and that it decidedly favors the employment of judicious and intelligently directed efforts to reduce the displacements in cases of dorsal and lumbar dislocations and fractures, as well as in those of the cervical region.

FRACTURES OF THE VERTEBRÆ.

Men suffer from traumatic lesions of the vertebræ, from fractures as well as from dislocations of these bones, much more frequently than women, because the former, by their occupations, are much more exposed to the various accidents in life which cause these lesions, than the latter.

Fractures of the vertebræ may be, (1) *simple*, (2) *compound*, (3) *comminuted*, and (4) *complicated*. By a *pure* fracture is meant a simple fracture, which is not complicated with a dislocation. Compound fractures of the vertebræ are chiefly caused by the impact of gunshot missiles. *Gunshot fractures* of the vertebræ are of frequent occurrence. They constitute a special class of injuries, and will be separately considered. All forms of spinal fracture are frequently, but not necessarily, complicated with injury of the spinal cord, as well as with dislocation.

An inspection of the recorded cases of spinal injury involving the vertebræ and not caused by gunshot missiles, that is, of the recorded cases which occur in civil life, shows that the lesions consist of pure fractures in about one-fifth of the instances, of pure dislocations in another one-fifth, and of dislocations combined with fractures in the remaining three-fifths.

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[1] Lancet, 1850.

[2] British Medical Journal, 1859.

[3] Medical News and Abstract, 1881, p. 105.

Pure fractures of the vertebræ are of rather infrequent occurrence in the cervical region. Of 36 cases observed at Guy's Hospital, and mentioned by Mr. Bryant, in which the cervical vertebræ were injured, there was no example of pure fracture, while there were 11 examples of pure dislocation, and 25 examples of fracture combined with dislocation. Still, pure fractures of the cervical vertebræ are sometimes met with. I have already presented one instance, and shall mention several others. But it is in the dorsal and lumbar regions that most cases of pure fracture of the vertebræ are found, the very regions in which pure dislocations of the vertebræ least frequently occur. However, pure fractures fall much short of the majority in even these regions; for, of 18 cases in which the dorsal, and 2 cases in which the lumbar vertebræ were injured, that were observed at Guy's Hospital, and are mentioned by Mr. Bryant, nearly two-thirds appear to have been examples of fracture and dislocation combined.

In the 25 cases of cervical fracture combined with dislocation that were noted at Guy's Hospital, the lesion was below the third cervical vertebra in all but three examples. In one of these, it involved the second, third, and fourth cervical vertebræ; in another, the arch of the atlas and the spinous processes of the second and third vertebræ; and, in the third case, the bodies and laminæ of the third, fourth, and fifth cervical vertebræ.

In the 18 dorsal cases, of all sorts, seven were in the upper and eleven in the lower half of the dorsal region. Thus, it seems clear that the lower parts of both the cervical and the dorsal regions are much more liable to fracture and dislocation than the upper parts.

The following case will serve to illustrate the most common form of fracture combined with dislocation, which is met with in the cervical region:—

On the morning of November 10, 1852, an unknown man, but poorly clad, was found lying dead on the cellar-bottom of an unfinished house at the corner of Franklin Street and Broadway, where it seems that he had fallen from the street, some time during the previous night. *Autopsy*, by the writer, at the Sixth Ward Station House, at 11 A. M., for the coroner.—Rigor mortis strong. Head and neck bent far forward. Spinous processes of the sixth and seventh cervical vertebræ movable. On exposing them by a free incision, the muscular and connective tissue around the sixth and seventh cervical vertebræ was found extensively infiltrated with blood. The spinous process of the seventh cervical (vertebra prominens) was broken short off. The laminæ of the sixth cervical vertebra were fractured at a little distance from the spinous process of that vertebra, which accounts for the mobility of this spinous process also. The body of the sixth cervical vertebra was luxated forward from that of the seventh. The intervertebral substance, the anterior and posterior common ligaments, the capsular ligaments, and the ligamenta subflava were all torn through. The spinal cord was crushed by the displacement, and the theca vertebralis contained much blood. Externally, the theca was coated with blood.

The fractures of the laminæ of the sixth, and of the spinous process of the seventh vertebra, were doubtless caused by striking the back part of the neck, at its root, upon the hard cellar-bottom; the laceration of the ligaments, and the displacement forward of the body of the sixth vertebra from that of the seventh, doubtless resulted from the extreme degree of flexion to which the spinal column was simultaneously subjected at the root of the neck.

Death quickly ensued, because of the cerebral concussion which attended the fall, and because of the shock which arose from the crushing of the spinal cord; but principally because of the extravasation of blood within the theca vertebralis, which speedily paralyzed the cord, by compressing it, as high as the roots of the phrenic nerves above the third vertebra, and thus completely arrested the respiratory movements.

This case is offered as an illustration, because, in most cases of fracture combined with dislocation that are observed in the cervical region, the laminæ, or the spinous or transverse processes, are fractured, the ligamenta subflava, the capsular ligaments, and the intervertebral disk are lacerated (more or less), and the body of the upper vertebra is thrown forward from that of the lower.

In the following example death suddenly resulted from falling upon the back in such a way as to crush three dorsal vertebræ, together with the spinal cord:—

Peter Riley, a laborer, fell from the walls of Trinity Chapel, then being built, on Saturday, November 27, 1852. He went down perpendicularly a distance of about fifty feet, and struck his back squarely across a beam. When picked up by his comrades immediately afterward, he spoke tenderly of his mother and sisters, and said "my back is broke." He died in about twenty minutes. At the *autopsy* I found the fourth, fifth, and sixth dorsal vertebræ much comminuted, that is, broken into many fragments. The muscles covering them were badly bruised and torn, and contained much extravasated blood. The skin, however, was not broken. An incision through the skin having been made, the soft parts investing these vertebræ were found so much disintegrated that, after picking out some fragments of broken bone, I thrust my fingers with ease directly through the spinal column into the right pleural cavity. The theca vertebralis and the spinal cord must also have been torn asunder.

The speediness with which death followed the injury in this case was due to shock, caused by the extent and severity of the spinal lesion itself, and to internal hemorrhage from the intercostal arteries that were torn, and, perhaps, from other sources. Professor Ashhurst[1] mentions a case taken from the Pennsylvania Hospital Records, which is somewhat similar to the last:—

A laborer fell from the sixth story, and thereby sustained a comminuted fracture of the lumbar vertebræ, fracture of the coccyx, and fractures of both legs. Death ensued in one day from exhaustion and internal (post-peritoneal) hemorrhage.

But comminuted fractures of the dorsal or lumbar vertebræ may be attended by rupture of the aorta, and death from internal hemorrhage may follow in the course of a few minutes. Several examples of this sort are on record:—

(1) Forster[2] mentions a case of Roper's, in which a man, aged 55, was knocked down and driven against by an omnibus. He was stunned, and in five minutes he died. Fracture of the fourth lumbar vertebra and laceration of the aorta were found. (2) Curling[3] mentions the case of a rigger, aged 54, who fell from masthead to deck, and died in fifteen minutes. The *autopsy* showed fractures at the first, second, and third lumbar vertebræ, with rupture of the aorta. (3) Curling[4] also reports the case of a wagoner, aged 46, supposed to have been run over by a wagon. He died in a few minutes. The *autopsy* showed fractures of the eighth, ninth, and tenth dorsal vertebræ; the aorta was ruptured. In such instances, however, the nature of the accident can often be correctly surmised from the seat of the fracture and the grating of the fragments, together with the sudden appearance of the signs of internal hemorrhage, such as a wax-like pallor of the countenance; lips bloodless, or dark-purple at their margins; cold sweats; weak, frequent, small, fluttering pulse; syncope, etc., ending quickly in death; but without any external flow of the extravasated blood.

Comminuted fractures of the dorsal or lumbar vertebræ are sometimes found to be compound, in consequence of the integuments and muscles being lacerated by the same exhibition of force which has caused the fractures themselves. Such fractures, probably, result most frequently from being crushed in railway collisions. "Brief mention is made in the reports of some instances of compound fracture of the spine from railway accidents."[5] No details, however, of these instances are published; but, such cases must almost inevitably prove fatal, and all that the surgeon can do for them is to mitigate suffering by administerining opiates and stimulants.

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[1] Op. cit., pp. 116, 117.

[2] Proc. Path. Soc. London, vol. viii.

[3] London Hosp. Reports, vol. i.

[4] Ibid.

[5] Circular No. 3, S. G. O., Aug. 17, 1871, p. 129.

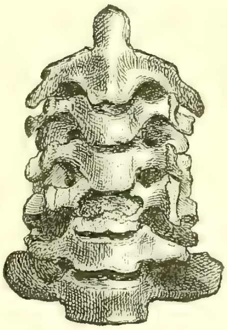
The following example will serve to illustrate one dangerous sequel which sometimes, perhaps often, presents itself in cases of simple vertebral fracture, namely, traumatic myelitis:—

Private John Hackey, Co. E, 6th Cavalry, aged 30, received, at Fort Waco, Texas, March 5, 1870, by falling from the second floor of a building occupied as barracks, a fracture of the fourth cervical vertebra. Complete paralysis, both sensory and motor, of the lower extremities, and of most of the trunk and upper extremities, immediately ensued. He was admitted to hospital without delay. But, on the morning of the 7th, he died of acute myelitis, about forty-eight hours after the accident. His intelligence remained unimpaired throughout. The treatment was sedative and stimulant.[1]

The paraplegia which immediately ensued, in this case, appears to have been due to concussion of the spinal cord, for no mention is made of compression of the cord from displacement of bone nor from any other cause. The symptoms of concussion ran quickly into the symptoms of acute inflammation of the spinal cord, and death soon ensued.

In the following instructive case, there occurred simple fracture of the fifth cervical vertebra, without displacement of the fragments, and compression of the spinal cord from extravasation of blood at and around the seat of fracture:—

Fig. 773.



Showing fracture, without displacement, of the body of the fifth cervical vertebra. (Spec. 5724, Sect. I, A. M. M.)

Private Emmet J., Co. A, 5th Infantry, aged 19, in diving from the bank of the Arkansas River, near Fort Lyon, Colorado, July 3, 1868, for the purpose of bathing, struck his head against the bottom, and immediately became powerless in the legs and arms. He would have drowned had no help been given. He was carried on a stretcher to the hospital, lying on his abdomen. Upon admission, at 1 P. M., the pulse, respiration, and temperature (although not counted) seemed normal; the pupils were unaffected; there was priapism. Power soon returned to his arms, although it was feeble. His extremities remained warm; and, when touched, sensation was found more acute, that is, less blunted, in the left than in the right leg. He complained of feeling dead below the neck. No irregularity or distortion of the spine was revealed by a careful examination; but, there was tenderness over the fifth cervical vertebra. A sinapism was applied to the nape of his neck; and, in an hour, he asked to be turned over, that is, on to the back. At 5 P. M. the pulse was 104; respiration 18; temperature 105°. Ice was applied to the upper part of the spine, a saline aperient was prescribed, and small pieces of ice given to be held in the mouth. At 9 P. M. the pulse was 100; respiration 24; temperature 102°; he was catheterized, and placed on a water-bed. On the morning of the 4th, the pulse, respiration, and temperature were all lessened. Cold applications to the spine were continued in the form of iced water, and the catheter was used twice during the day. At 5 P. M. the bowels were moved involuntarily. On the 5th, the temperature sank considerably below the normal (Fig. 774); sensation in the lower extremities was abolished; and the respiration was abdominal, that is, diaphragmatic. Dry rubbings were prescribed, with tonics, and nutritious food. On the 6th, sensation had partly returned to the left leg, and the breathing was better, there being more movement of the chest. By the 11th, the patient was able to pass his urine without a catheter, but sensibility did not return to the right leg. On the morning of the 13th, he had a chill, which recurred on the morning of the 14th, and again in the afternoon. After this, his countenance became dusky, and the temperature rose during the next three or four days. He had not perspired since the injury. On the morning of the 18th, the urine became turbid, the stomach was irritable, and he complained of his lungs feeling like stone. By the morning of the 20th, the pulse had become so feeble that it could not be counted, the bowels were loose, the urine was ammoniacal and thick with mucus, and vomiting occurred. Increased respiration and a very high temperature (105°) followed. On the 21st, catheterization had again to be employed, but the instrument was used with difficulty, owing to the formation of coagula in the bladder. He also suffered from bed-sores. By the 24th, his stomach became so irritable as to retain scarcely anything. On the 25th, there was complete anorexia. On the 26th, the temperature was 91.8°. He died at noon on the 28th. *Autopsy.*—Brain normal. The body of the fifth cervical vertebra was found fractured (Fig. 773). There was no displacement of the vertebra. It was ascertained that hemorrhage had compressed the spinal cord at and around the seat of fracture. In the dorsal region, the spinal canal showed no abnormity, excepting the spinal fluid which escaped. It was filled with transparent, floating globules, and resembled volatile-oil water. Lungs healthy, excepting the posterior portions, which were hypostatically congested; liver slightly enlarged. Splenic extremity of stomach congested. The kidneys were enlarged and engorged with blood; the pelvis of the left was filled with pus; but no other abscess could be found. The ureters were very dark in color, and one of them contained a clot at the entrance to the bladder. The walls of the bladder were dark-purple in color, inflamed, and thickened; its mucous membrane was absent in patches. The pathological specimens were sent to the Army Medical Museum.[1]

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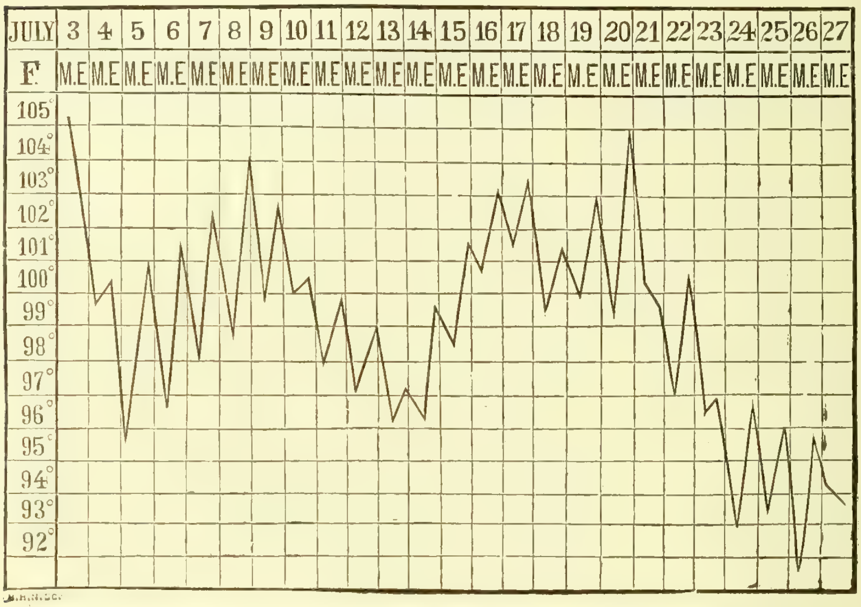
[1] Circular No. 3, S. G. O., Aug. 17, 1871, p. 129.

Fig. 774.



Thermograph of a fatal case of fracture, without displacement, of the fifth cervical vertebra.

Viewing the clinical history of this case in the light thrown upon it from the autopsy, the paralysis which instantly followed the injury appears to have been due to concussion of the spinal cord, and it may well be that injuries of a similar character, involving the upper part of the spinal column, are often attended by spinal concussion. However, the paralytic symptoms that were due to concussion soon began to pass away, and on the following day were succeeded by the symptoms of compression of the spinal cord, caused by hemorrhage into the spinal canal, which increased in severity until sensibility as well as motor power was abolished in the lower part of the body, the respiration becoming diaphragmatic from paralysis of the other respiratory muscles, and the patient's temperature sinking to 95.8° on the morning of the second day. Then, the hemorrhage having ceased, the absorption of the extravasated blood was immediately commenced, and it was continued with so much activity that on the following day, July 6, sensation had partly returned to the left leg, and the respiration was better, for all of the chest-muscles again participated in the respiratory movements. By the 11th, he was so much improved that his micturition was entirely voluntary. But the sensibility did not return to his right leg, and this circumstance showed that the conducting filaments of the spinal cord itself were considerably injured, probably by contusion and ecchymosis of the cord-substance. On the 13th, or two days later, consecutive spinal meningitis and myelitis began with a chill, after which the patient's temperature rose considerably above the normal, and his countenance became dusky from vaso-motor paralysis. By the 20th, the inflammatory lesion of the spinal cord and membranes was attended by trophic lesions of the urinary bladder and kidneys, and of the soft parts over the sacrum and buttocks, which will hereafter be described under the head of Acute Bed-sores, and of Disorders of the Urinary Organs from Lesions of the Spinal Cord. The blood found in the bladder on the 21st had probably flowed into that organ through the ureters from the kidneys. The patient's stomach soon gave out entirely, and in a few days more he sank exhausted from vesical and renal inflammation, and from acute bed-sores.

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[1] Circular No. 3, S. G. O., August 17, 1871, pp. 129–131.

The thermograph of this case (Fig. 774) shows at a glance three remarkable periods of depression in the temperature, the first of which corresponded to the compression of the spinal cord by extravasated blood (July 3 and 4); the second, to the invasion of the spinal cord and spinal meninges by consecutive inflammation (July 12, 13, 14); and the third, to the occurrence of exhaustion as the end drew near. After the first and second periods of depression, the temperature rose considerably.

By what symptoms externally perceptible was this fracture attended? By one only, to wit—by tenderness under pressure over the fifth cervical vertebra. In the absence, however, of distortion or deformity, or other evidence of luxation, the presence of fracture should be suspected in cases such as this. But the occurrence of spinal paralysis under such circumstances should not, *per se*, cause a fracture of the vertebræ to be surmised, since the paralysis might just as well result from concussion or contusion of the spinal cord, as it did in fact at the outset of this case. The spinal column was suddenly bent until it broke at the fifth cervical vertebra, but the fragments instantly sprang back into place again. At the same moment, the spinal cord was bent, stretched, and bruised; the spinal arteries were ruptured, hemorrhage therefrom ensued, and thus the symptoms of compression readily succeeded the symptoms of concussion of the spinal cord.

Besides these dangers, that is, contusion and compression of the spinal cord, together with spinal meningitis and myelitis, fractures of the upper cervical vertebræ are attended by others. Should the cord be crushed, or even pierced, above the roots of the phrenic nerves by a fragment of displaced bone, the respiratory movements would at once cease entirely, because the respiratory muscles would all be paralyzed, and death from asphyxia would immediately ensue. This accident not unfrequently happens, and the victims thereof but seldom, comparatively, receive the attention of surgeons. Abernethy, however, is credited with mentioning the case of a coal-heaver who fell from a wagon while drunk. There was no apparent injury; still, he could not rise in bed; and, in turning his head to be shaved, he suddenly died. Fracture of a cervical vertebra was found; and the cord was penetrated by a splinter. The lesion must of course have been not lower than the third cervical vertebra.

Professor William Pepper[1] relates the case of a girl, aged 19, who broke her neck by falling from a pie-cherry tree, and was admitted to the Pennsylvania Hospital twenty-four hours afterward. All power to move the extremities and muscles of the trunk was gone. Sensation, too, was entirely lost from a little below the clavicle downward. There was retention of feces and urine; the bladder was much distended, no urine having been passed since the accident. The respiration was entirely diaphragmatic, and 32. The facies indicated great respiratory oppression. Pupils normal; intellect clear; voice feeble, and frequently interrupted; the tongue could be protruded at will, and moved in any direction. The cheeks were brightly flushed and very hot. The skin everywhere was much hotter than normal; pulse, small and frequent; temperature in axilla, 108.5°. "She abruptly asked to be raised in bed; her breathing became gulping and imperfect, and in less than two minutes she fell back dead." Pulsation was still perceptible at the wrist almost one minute, and the cardiac sounds were yet audible between three and four minutes, after the last respiration. *Autopsy.*—The tissues surrounding the cervical vertebræ were ecchymosed, and infiltrated with bloody serum, but no blood had escaped into the pharynx. There was a comminuted fracture of the atlas, the lateral masses being separated and the arches broken in two places. The fourth vertebra was luxated anteriorly from fracture of the articular processes.

The paraplegia which attended the accident was due to the forward luxation of the fourth cervical vertebra. The flushing of the face, and the great elevation of the body-heat were due to vaso-motor paralysis which resulted from injury of the sympathetic nerve. The sudden death was caused by puncturing the spinal cord with fragments of the broken atlas, and compressing it against the odontoid process of the axis. Not improbably, the girl's head slipped forward on the summit of the spinal column, when she was raised up in bed. The same accident occurred to this patient, on being raised up in bed, as befell one of Mr. Hilton's patients and nearly happened to another (whose cases have already been mentioned), where the ligaments belonging to the articulatio capitis had been so extensively destroyed by disease, as to allow the head to slip forward and compress the spinal cord, with deadly effect, against the odontoid process of the axis. The sudden death of the patient whose case has just been related shows, that the same care is needed in cases of injury and in cases of disease of the first vertebra, alike, if the spinal cord be liable to sudden compression from the slipping or falling forward of the head, in consequence of the injury or the disease.

The following example teaches the same important lesson:—

Dr. H. F. Eberman,[2] reports the case of a man, aged about 70, who, while descending the steps from a hay-loft, slipped and fell, striking his occiput violently on the ground, and forcibly bending his head forward on to his chest. He lay insensible, for a considerable time. But, after recovering from the stunning, he arose, and placing both hands to his neck, walked to the bar-room of the hotel (half a square from the place of accident), where he remarked that he thought his neck was hurt, asked for a glass of whisky, and drank it. Then, he returned to the stable, and lay down on some hay; in about half an hour he expired. *Autopsy.*—The transverse process on the right side of the atlas was found to be broken off; the third cervical vertebra was fractured transversely through its body, the right arch was broken entirely through, and the articulating processes on both sides were fractured through the middle; the inter-spinous and posterior vertebral ligaments were ruptured; but the spinal cord remained intact.

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[1] Am. Journ. Med. Sciences, April, 1867, pp. 438, 439.

[2] Ibid., October, 1879, p. 590.

The sudden death of this man, too, was due no doubt to a compression of the spinal cord against the odontoid process of the axis, which was suddenl caused by the elevating or thrusting forward of his head, and the subsidence of his neck, that would naturally occur when he turned over upon his back, as he lay flat on the hay, without a pillow to keep the nape of his neck raised up sufficiently to avoid such a calamity. This displacement of the fragments of the broken atlas, etc., could have been avoided by placing a small firm pillow under the patient's neck, when putting him to bed, and by confining his head and neck in a fixed position by means of heavy sand-bags so placed on either side thereof as to prevent all motion in the neck, as recommended by Mr. Hilton in analogous cases of cervical disease. Had such a proceeding been instituted, in this case, and continued until consolidation of the fractures had been effected, recovery no doubt would have ensued. The following example shows not only that this view is correct, but also that spontaneous recovery from similar fractures sometimes occurs:—

A man, aged 32, fell from a hay-wagon, striking his occiput on the ground, and was stunned.[1] He walked half a mile to visit a surgeon; in three days he resumed work; his neck was stiff, and there was tumefaction over the axis; after several months, dysphagia and tumefaction in the pharynx appeared. Nevertheless, he recovered; and, about one year and a half after the accident he died of pleurisy. The *autopsy* showed fractures of the atlas and odontoid process of the axis. (Ashhurst.)

As a symptom of the fractures of the atlas and third cervical vertebra which had occurred in Dr. Eberman's case, it may be mentioned that the man walked with a hand placed on each side of his neck, apparently in order to support it. Sir Astley Cooper[2] relates a case of simple fracture of the atlas, that was under the elder Cline's care, in which the same symptom was present:—

"A girl received a severe blow upon her neck; after which it was observed that, whenever she wanted to look at any object, either above or below her, she always supported her head with her hands, and then gradually and carefully elevated or depressed it, according as she wished, towards the object. After any sudden shock she used to run to a table, and placing her hands under her chin, rest them against the table, until the agitation caused by the concussion had subsided. Twelve months after the accident the child died; and on examination, a transverse fracture of the atlas was found, but no displacement. When the head was depressed or elevated, the dentiform process of the second vertebra became displaced, carrying with it a portion of the atlas, and occasioning pressure on the spinal marrow, which was also produced by any violent agitation."

Fractures of the odontoid process, as a rule, suddenly destroy life; the victims being literally pithed by that process. This accident often, but not always, proves instantly fatal.

For example, Melchiori[3] mentions the case of a woman, aged 68, who was killed by falling from a ladder and striking her forehead on the ground. Death was instantaneous. *Dissection* showed fractures of the atlas and odontoid process of the axis; and the atlas was displaced backward. (Ashhurst.)

When, however, it happens that the fragments of the broken odontoid process are not displaced sufficiently to injure the spinal cord, the patient may survive until such a displacement is produced by some accident or other, as doubtless occurred in the following instance:—

Richet[4] relates the case of a man, aged 22, who attempted suicide by a pistol-shot in the neck. He survived the injury for seventeen days, during which time he could move only by supporting his head with his hands. Death suddenly occurred. *Dissection* showed fracture of the odontoid process. (Ashhurst.)

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[1] Am. Journn. Med. Sciences, O. S., vol. xxiii.

[2] Lectures, vol. ii. p. 8.

[3] Gaz. Medica Stati Sardi, 1850,

[4] Thèse de Concours, 1851.

Professor Willard Parker, of New York, some years ago, had the case of a milkman, aged 40, who was injured by being thrown from a wagon about fifteen feet, and striking his head and face on the ground. There was pain in the neck and a protuberance on the left side thereof. He could not turn his head, but supported it with his hands. He got so well that he resumed his milk business, and survived the injury for five months. He died suddenly, after a hard day's work, on the fragments becoming displaced by an accident, his head dropping forward upon his chest, at the table, to such a degree as to compress the spinal cord. *Dissection* showed fracture of the odontoid process; and the lower end turned back to the spinal cord.

This patient would have recovered had he but kept his head and neck at perfect rest until consolidation of the fracture had ensued. In the following example recovery did take place, and some time afterward the man died of a non-surgical disorder:—

Mr. B. Phillips[1] had under his care a laborer, aged 32, injured by falling head foremost from a hay-rick. In a little while he was able to arise. In two days he went to work again. A month afterwards, he walked two miles to consult his surgeon. His neck was stiff, there was a protuberance at the back of the pharynx, with some difficulty in swallowing, but no paralysis. One year after the accident he died from dropsy. The *autopsy* showed fractures of the atlas and odontoid process, with displacement of some pieces forward against the pharynx; the occipital bone had settled down on the axis, and formed a new joint; the spinal cord was unhurt. The spinal foramen in the first and second vertebræ is quite large; and, therefore, these bones may be extensively damaged without seriously injuring the spinal cord.

Mr. R. Debenham[2] also mentions a case in which the odontoid process was fractured, and recovery followed. The subject was a shoemaker, and the lesion was verified by dissection two years after the accident. Cases in which the odontoid process was spontaneously fractured, that is, fractured in consequence of disease, have been reported by Hyrtl, by Else, and by Flint; and, in each instance, death occurred instantaneously.[3]

Professor Stephen Smith, in an article on "Fracture of the Odontoid Process,"[4] has collected twenty-two cases. Six occurred spontaneously, in consequence of disease, and all ended fatally except one, in which a portion of the bone was discharged through the throat; four were gunshot cases, all fatal; seven were caused by external violence, all likewise fatal; five were cases in which a portion of the bone had been discharged, with four recoveries and one death; aggregating but five recoveries and seventeen deaths. Dr. Smith has found, by experiment, that, although the odontoid process is not fractured by being driven against the transverse ligament on the anterior arch of the atlas, the odontoid ligaments combined are stronger than the odontoid process, and "that the efficient agents in this fracture are the odontoid ligaments." The odontoid process has been fractured from violence directly applied; and from external violence indirectly applied, *e.g.*, to the forehead, to the side of the head, and to the back part of the neck. The symptoms of this accident are pain and stiffness in the neck, swelling in the region of the first and second vertebræ, and a protuberance in the pharynx at the same region; but, probably, the chief symptom is that the patient carries the head supported on the two hands. This symptom, however, has been observed in cases where the occipito-atloid articulation, that is, the *articulatio capitis*, has been disrupted, as well as in cases where the bones forming the atlo-axoid articulations have been broken; and, generally, it denotes that either the atlas, or the axis, or both of these bones are fractured.[1]

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[1] Medico-Chirurgical Transactions, vol. xx. p. 78.

[2] London Hosp. Reports, vol. iv. p. 210.

[3] P. Bevan (Dublin Med. Press, February, 1863) reports a case in which there was fracture of the odontoid process, perfect anchylosis of its apex with the occipital bone, and partial luxation forward of the atlas. (New Syd. Soc. Year-book, 1864, p. 280.)

[4] American Journal of the Medical Sciences, October, 1871, pp. 338–58.

"*Latent Fracture of the Spine*," as Mr. Simon has denominated an important lesion of the spinal column which occasionally presents itself to surgeons, must also be considered in connection with those fractures of the vertebræ which are attended by but little or no displacement of the fragments. In the examples of so-called latent fracture of the vertebræ, the spinal cord is not at all affected by concussion, nor by contusion, nor is it compressed by displaced bone, nor by extravasated blood. The breach, in these cases, usually consists of a linear fracture through the body of a cervical or a dorsal vertebra. On the withdrawal of the force which fissures the bone, the fragments at once spring back into place again. The patient complains only of pain, soreness, and stiffness in the injured part of the spine, for some days; and, perhaps, having returned to work, continues at the same until the symptoms of suppurative inflammation present themselves at the seat of the fracture, and until an abscess forms in the spinal canal between the theca vertebralis and the bone, as well as external to the bone, in the same locality. These cases are strictly analogous to those of circumscribed abscess occurring between the dura mater and the bone, in consequence of a linear fracture of the skull, which have often been observed in latent injuries of the head. As subcranial abscesses not unfrequently cause death, *per se*, by compressing the brain, even so these cases may terminate in death by compression of the spinal cord, without the occurrence of that diffused traumatic spinal meningitis or myelitis which often supervenes, as we have already shown, in cases of vertebral fracture or dislocation. Mr. Simon[2] relates an instructive example of the spinal lesion in question:—

A girl, aged 18, injured her neck by falling, in the dark, about twelve feet down an embankment. At first she was stunned. Afterward she walked home, a distance of about three miles. She resumed work, and remained thereat for eleven days. She entered St. Thomas's Hospital on the fifteenth day after the accident, on account of severe pain in her neck, with fever, etc. No displacement nor irregularity of the spine could be detected. There was no anæsthesia nor paralysis. Her complaints of pain and tenderness were vague. She chiefly spoke of suffering between the shoulders; turning over into a prone position in bed was accomplished slowly, stiffly, and with cries. Early on the sixteenth day, she complained of numbness and twitching in her limbs, particularly in the lower; in the evening, voluntary motion was lost completely in the legs, and nearly in the arms; sensibility was likewise very much impaired in both. Delirium, "jumping of the legs," and tympanitic distension of the abdomen, as well as high fever now appeared. On the eighteenth day she died. *Autopsy*, 30 hours after death—"A horizontal line of fracture was found traversing the body of the seventh cervical vertebra, just above its inferior surface. Beyond a very little gaping in front, which would allow the edge of a scalpel to be insinuated flatly between the fragments, there was not the slightest displacement; and the posterior common ligament was untorn. The spinal canal contained between the osseous walls and the dura mater [theca vertebralis] a large quantity of pus, which, from two inches below the foramen magnum, descended the whole length of the cord. At the several intervertebral holes it had crept somewhat along the issuing nerve-sheaths, and, between the first and second dorsal vertebræ had actually emerged, following the subdivision of the first dorsal nerve, so as to spread among the exterior parts. These burrowings of matter were cut into before the [spinal] canal was opened. . . . The outer surface of the [spinal] dura mater was roughened by inflammatory deposits; but none were found within it; nor was there any softening, or microscopical change in the spinal cord. No other disease was discovered."

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[1] But fracture of the axis unattended by any notable displacement may prove quickly fatal, by causing hemorrhage into the spinal canal, and compression of the spinal cord therefrom, as happened in the following instance: Arnott (Lancet, 1851) reported the case of a man, aged 74, injured in the neck by falling down stairs. There was paralysis of the upper extremities, but not of the lower. In one hour death ensued. *Dissection* showed fracture of the spinous process of the axis; the fragment was wedged in between the axis and the third vertebra. There was effusion of blood in the vertebral canal. (Ashhurst.)

[2] Transactions of the Pathological Society of London, vol. vi. p. 42.

The fracture of the seventh cervical vertebra was called latent, or concealed, in this case, because it was not attended by deformity, nor by any other symptom of special import, for a considerable number of days. Meanwhile, the connective tissue lying between the theca vertebralis and the bone became inflamed, commencing at the fracture, and purulent matter in great quantity was formed and collected in this tissue, whereby the spinal cord was compressed through the medium of the theca; but life was not destroyed until the intra-vertebral abscess had burrowed upward far enough to compress and paralyze the respiratory centres, thus arresting completely the respiratory movements and causing death by asphyxia. The abscess external to the spinal column was not large in this case. In other instances, however, the exterior abscess is found to be quite large, and to burrow extensively in the soft parts around the spinal column, as was noted in the following instance:—

Sir B. C. Brodie[1] mentions the case of a man, aged 45, who fell from a scaffold and injured his back. There was paralysis, followed by convulsions. Death ensued nine weeks after the accident. *Dissection* showed fracture of the fourth dorsal vertebra; the spinal cord was compressed and softened; an abscess arising from the seat of the fracture extended into the posterior mediastinum. (Ashhurst.)

It is not the fracture itself which destroys life in these cases of latent vertebral injury, but the consecutive inflammation and abscess; and, if these untoward consequences of such injuries be averted, complete recovery will ensue. The symptoms directly after the injury, in cases of latent fracture of the spinal column, closely resemble those which are met with in sprains or wrenches of the vertebral joints, caused by blows on the back, falling, etc.

Mr. Bryant[2] mentions, in point, the case of a woman admitted into Guy's Hospital, under Mr. Cock's care, for some injury of the back caused by falling out of a window. "Beyond the contusion, no injury could be made out." She died, however, of cerebral disease sixteen days after the accident. *Dissection* showed that the last dorsal and three upper lumbar vertebræ were fractured through their bodies, but not displaced; one or two spinous processes were also fractured. The spinal marrow was uninjured. The fact of there being no displacement of the broken bones, and no injury of the spinal cord, had prevented the making of a correct diagnosis in this case.

But examples, such as this, of vertebral fracture wherein the diagnosis is not made until the post-mortem examination, are not uncommon. It is, therefore, rather important for the surgeon to bear the latter fact in mind while treating cases of supposed sprains, wrenches, and twists of the vertebral joints, and to enforce, in all doubtful cases, that absolute quietude of body—that freedom from all movement, particularly in the injured portion of the spinal column—which is necessary in order to secure consolidation of the fracture without accident, should this lesion perchance be present.

In cases of vertebral fracture occurring in the dorsal region, it should be stated that displacement of the fragments is measurably prevented by the ribs acting as splints placed on each side of the spinal column. In the lumbar region, likewise, the great lumbar muscles may act powerfully in the way of preventing and removing displacement, in cases of vertebral fracture unattended by dislocation, as the following example will show:—

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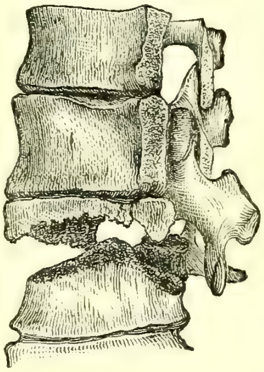
[1] Medico-Chirurgical Transactions, vol. xx.

[2] Op. cit., p. 202.

Corporal John B., Company C, 10th New York Volunteers, March 11, 1865, at Hatcher's Run, Va., was struck across the dorsal and lumbar regions by the falling limb of a tree which had been severed by a shell. He was knocked senseless, and remained so an hour or more, until he was awakened by the jolting of the ambulance that carried him to regimental headquarters. On regaining consciousness, he was unable to move the lower portion of his body, and complained of pain in the same parts. He was cupped, and had mustard applied to the calves of his legs and to the spinal region. The symptoms still continuing, he was blistered, and the blisters were dressed with lint. On the 19th, he entered Finley Hospital, at Washington; he was then semi-comatose; there was complete motor paraplegia, but sensation was perfect. There was some febrile action, pulse full and bounding, and very severe diarrhœa; feces and urine passed involuntarily; both legs were very cold, the left slightly more than the right; skin moist, the blistered parts on each leg were suppurating slightly. The parts in the region of the sacrum were gangrenous. Opiates were given at night, and chlorides used to cleanse the gangrenous sore over the sacrum. Under the administration of astringents, the diarrhœa ceased by the 25th. The patient, however, continued to sink, and died on the 29th, apparently from exhaustion (septicæmia?).

Fig. 775.



Pure or simple transverse fracture of the first lumbar vertebra, caused by the limb of a tree falling upon the loins and back of a soldier. (Spec. 149, Sect. I, A. M. M.

Autopsy.—The first lumbar vertebra was found fractured entirely through its body at the upper third (Fig. 775), with each pedicle broken, and the left transverse and spinous processes impinging against the spinal cord, which was lacerated at the lumbodorsal junction. The spinal meninges were torn entirely across, excepting a few fibres anteriorly and posteriorly, and were congested above and below the rent. Blood-clots were found diffused in the tissues around the fracture. The spinal cord was lacerated in a singular manner, and a wood-cut representing it (Fig. 792) is given on p. 803.

In this example, the fracture of the vertebral column, although it extended completely through the same (Fig. 775), and constituted a false point of motion, appears to have not been recognized until the examination after death. The principal cause of this failure to make a diagnosis, appears to have been the fact that there was no appreciable displacement. Thus, the spinal symptoms were supposed to arise from concussion of the spinal cord; and the illusion itself was furthered by the fact that the paralysis was motor, but not sensory. The occurrence of displacement seems to have been prevented by the action of the lumbar muscles.

Three cases of pure fracture of the dorsal and lumbar vertebræ are mentioned by Mr. Bryant.[1] In one of them the fourth and fifth dorsal vertebræ were comminuted; in another, the eighth, ninth, and tenth were fractured through their bodies and laminæ; and, in the third, the twelfth dorsal and three upper lumbar vertebræ were extensively broken. In one of them certainly, and in all of them possibly, no displacement was to be detected by an external examination. The fragments appear to have been held in position by the ribs, and by the great muscles which are in relation with the spinal column in the dorsal and lumbar regions.

But in other instances of pure dorsal and lumbar fractures, the displacement of the fragments is such that it can readily be perceived on making an external examination. For example:—

Dr. H. J. Bigelow[2] gives the case of a young woman, aged 19, who jumped from a second-story window, and alighted upon her buttocks, thereby fracturing her spine. There was a projection of the lower dorsal vertebræ and paralysis. The latter diminished after two weeks, and partial recovery ensued. In eight and a half months, however, she died of phthisis. The *autopsy* showed fractures of the last dorsal and of the first and second lumbar vertebræ; the spinal cord was compressed; provisional callus had formed. (Ashhurst.) It is worthy of special note, in this case, that the patient partially recovered, and that the disease which caused her death was not connected with the injury.

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[1] New Syd. Soc. Retrospect, 1867–8, p. 276.

[2] Am. Journ. of the Med. Sciences, N. S. vol. xxi.

Fractures combined with dislocation often occur in the dorsal region. They generally take place between the tenth, eleventh, and twelfth dorsal vertebræ. In such cases the body of the superior vertebra is usually dislocated forward, and the body of the inferior vertebra fractured; the arch of the inferior vertebra is, as a rule, also broken. (Bryant.) A specimen showing dislocation of the first, and fracture of the second lumbar vertebra, taken from a patient who had survived the accident for three and a half years, is described and figured by Mr. W. Wagstaffe.[1]

Fractures of the spinous processes, unattended by dislocation or by fracture of any other portions of the vertebræ, that is, pure fractures of the spinous processes, not unfrequently occur. They are met with in the cervical, the dorsal, and the lumbar regions alike, and are always caused by the direct application of force. They may be simple or compound; and compound fractures of the spinous processes are often caused by the impact of small-arm missiles. Generally, pure fractures of the spinous processes are not attended by spinal paralysis. When, however, spinal symptoms are present, in such cases, they usually arise from concussion of the spinal cord, though, in some rare instances, they have been found to be due to compression of the spinal cord by extravasated blood. Generally, pure fractures of the spinous processes, whether simple or compound, terminate in recovery without giving much trouble. I have seen a considerable number of examples belonging to the latter category,[2] and cannot now call to mind any case among them that did not end favorably. In one instance, there was severe concussion of the spinal cord also, and a fragment of the broken spinous process exfoliated. The experience of other observers supports the view that pure fractures of the spinous processes generally terminate in recovery without much difficulty.

Sir A. Cooper[3] mentions the case of a boy injured by thrusting his head between the spokes of a wheel. There was distortion of the spine, and fracture of three or four spinous processes, but no paralysis. "He quickly recovered without any particular attention." The deformity, however, remained. (Ashhurst.)

"When I was a dresser," says Mr. Bryant, "I saw a case of fracture of the spinous processes of three cervical vertebræ associated with a temporary paralysis; and, in this instance, complete recovery ensued; I have since successfully treated a case of fracture and displacement of the spinous process of the fourth cervical vertebra, without paralysis. . . . I have seen also a case of fracture of the spinous processes of the last dorsal and first lumbar vertebræ with lateral displacement, the injury having been treated for some months previously as a simple contusion of the back. In this case, no paralysis existed or other spinal symptoms."[4]

On the other hand, when perchance the broken-off portion of the spinous process gets impacted between the laminæ, and presses upon the spinal cord, death sometimes quickly ensues.

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[1] Trans. of the Patholog. Soc. of London, vol. xxi. p. 327.
[2] Am. Journal of the Med. Sciences, October, 1864, pp. 315, 327.
[3] Disloc. and Fract. of Joints.
[4] Practice of Surgery, p. 201.

For example, Mr. Erichsen mentions the case of a woman admitted into University College Hospital, with an injury of the neck, the nature of which could not be accurately ascertained. She was in no way paralyzed, but kept her head in an immovably fixed position. A few days after admission, whilst sitting up in bed, being startled by a noise, she suddenly turned her head, and fell back dead. *Dissection* showed that the spinous process of the fifth cervical vertebra was broken off short at its root, and was impacted in such a way between the arches of this and the arches of the fourth vertebra as to compress the cord.[1] The impaction of the fragment and the compression of the spinal cord probably occurred at the instant of the involuntary movement of the head.

I have already presented, in a foot-note, a somewhat similar case of Mr. Arnott's, in which a man, aged 74, fell down stairs and injured his neck. There was paralysis of the upper extremities, but not of the lower. In one hour death ensued. *Dissection* showed that the spinous process of the axis was fractured, and that the fragment was wedged in between the axis and the third vertebra; there was also effusion of blood in the vertebral canal, which probably caused death by compressing the cord. Notwithstanding these exceptions, the rule concerning the result in cases of pure fracture of the spinous processes, is as already stated, namely, that they generally end in recovery. Professor Agnew mentions the case of a young man, under his own care, in which the detached portion of a spinous process remained for several months movable, finally became necrosed, and was discharged through a sinus.[2]

Symptoms and Diagnosis of Fractures of the Vertebræ.—When the fracture is *compound*, as it is in cases where small-arm missiles break the spinal column, the diagnosis can generally be settled with certainty by exploring the wound with the finger. In cases where the aperture in the integuments is not large enough to admit a finger, *e. g.*, wounds made by buckshot and small pistol-balls, the exploration may be made with the porcelain-tipped probe of Nélaton, or with the ordinary bullet-probe, and thus, likewise, the lesion of bone, if it be present, can generally be made out. In cases where the orifice of the wound is too far away from the spinal column to admit of examining it with a finger in the wound, the exploration must be made with a probe, in order to determine whether there is a fracture of the vertebræ or not; and, in case there is, what part or parts of the vertebræ are broken.

Simple fractures of the *spinous processes* are attended by the following phenomena: Ecchymosis of the integuments covering the seat of fracture, pain and tenderness under pressure, also at the seat of fracture, with displacement and abnormal mobility of the broken spinous processes. If these be grasped by the thumb and fingers, they can be swayed from side to side, and the grating of the broken surfaces against each other will be felt by both patient and surgeon, as these movements of the broken-off portions of the spinous processes are made. But abnormal mobility may be imparted to the spinous processes from fractures of the corresponding pairs of laminæ to which they are attached, as was noted in at least one of the cases above mentioned. Mobility of the spinous processes arising from this cause, however, is not very liable to be mistaken for mobility arising from fracture of the processes themselves, inasmuch as there are essential differences between the false points of motion in the two cases; and no one having once had his attention called to the subject, would be likely to mistake the abnormal mobility of the vertebral spines which may result from fractures of the laminæ they are attached to, for that which results from fractures of the spinous processes themselves. Again, when the patient bends the injured part of the spine strongly forward, and thus greatly increases the tension of the integuments over it, as well as the disposition of the spinous processes to separate from each other, the deformity is correspondingly increased and the sufferings are correspondingly aggravated, in cases where the spinous processes are fractured.

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[1] Science and Art of Surgery, p. 291, Am. ed. 1854.

[2] Op. cit., vol. i. p. 825

Simple fracture of the *laminæ*, with displacement forward of the fragment embraced between the two lines of fracture, may be produced by a blow upon the spinous process which springs from them. This lesion is denoted by ecchymosis of the integuments, by local pain, stiffness, and tenderness under pressure, by depression of the broken laminæ themselves as well as of the spinous process attached to them, and by feeling the broken laminæ move when the corresponding spinous process is moved from side to side. In such cases, the spinal cord is liable to be seriously injured by the depressed fragments of the broken laminæ; and, therefore, the symptoms of spinal paralysis are usually present whenever the laminæ are fractured. In such cases, too, the patients themselves will feel the grating of the fragments, and will be likely to inform the surgeon to that effect if inquiry be made concerning it. Moreover, the surgeon should be very careful in regard to making pressure upon the spinous processes and bending them from side to side, in such cases, lest he may himself crush the spinal cord, or do some other irreparable injury to it. Oftentimes, the spinal cord is severely injured by the accident itself, in such cases, as the following examples will show:—

Dr. T. B. Ladd[1] reports the case of a man, aged 30, whose neck was injured by being thrown in wrestling, etc. There were paralysis, pain, fever, and dyspnœa before death, which occurred thirty-six and one-half days after the injury. *Dissection* revealed a fracture of the arch of the fifth cervical vertebra; the spinal cord itself was compressed and disorganized. (Ashhurst.) The spinal cord appears to have been severely compressed by the fractured laminæ, and disorganized by ascending myelitis. No doubt death was preceded by diaphragmatic breathing and paralysis of the respiratory muscles, in consequence of the respiratory centres being invaded by the myelitis. Likewise, Professor Hamilton mentions in his excellent Treatise on Fractures and Dislocations, the case of a man, aged 40, injured by a balustrade striking on his neck and head. There was paralysis, pain, etc.; and, in thirty-six hours, death ensued. *Dissection* showed fracture of the arch of the sixth cervical vertebra; the cord was compressed. It is not improbable that, in this case, death was directly caused by acute ascending myelitis.

Simple fractures of the *bodies*, *pedicles*, *transverse*, and *articular processes* of the vertebræ are more deeply covered up by muscles, fasciæ, and integuments, than the fractures just discussed; and, therefore, are diagnosticated with much greater difficulty. Generally, they cannot be separated from each other with certainty during life. They are attended by the following symptoms: Impairment of function, pain, and tenderness under pressure at the seat of fracture, subtegumentary extravasation of blood, more or less displacement of the fragments (sometimes it is very slight), and crepitus. The last-mentioned is the most important of all the signs; and, when distinctly felt, it removes all doubt as to the diagnosis of the fracture. But, while it is not allowable for surgeons to flex and extend, or to rotate and compress, the spinal columns of their patients merely for the purpose of ascertaining, by a manual examination, whether there be crepitus, nevertheless, this point can generally be settled by asking the patients themselves whether they have felt the "grating" of broken bones in the injured part, and by applying a flexible stethoscope, or the hand, over the injured place, while the patient is being turned over in bed in order for the nurse to cleanse the private parts, or while he is being moved for any other necessary cause. Thus, the surgeon by watching for an opportunity to make a manual examination, can generally settle the question of crepitus, without violating any canon of his art. The following examples will illustrate in a useful manner the symptomatology of these vertebral fractures:—

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[1] Boston Med. and Surgical Journal, 1852.

Dr. F. H. Hamilton, Jr.,[1] reports the case of a soldier, who fell twenty feet, striking his neck. There were crepitus over the second and sixth cervical vertebræ, with slight pain and paralysis, and a compound fracture of the thigh, unperceived by the patient. Death ensued forty hours after the accident. *Dissection* showed fractures of the spinous processes of the second and the third, and a longitudinal fracture of the body of the sixth cervical vertebra; the spinal cord was compressed. (Ashhurst.) Dr. Hiram A. Prout[2] mentions the case of a man, aged 30, who was injured in the neck while wrestling. There were paralysis, pain, and crepitus over the fifth cervical vertebra; and, forty-eight hours after the casualty, death occurred. *Dissection* revealed a fracture of the fifth cervical vertebra, the spinal cord compressed, and an effusion of blood in the spinal canal. (Ashhurst.) Professor Hamilton, in his excellent Treatise on Fractures and Dislocations, refers to the case of a man, injured in the neck by being thrown backward from a wagon, and striking his head. There was paralysis, with crepitus in the upper part of the cervical region; and his breathing nearly ceased when he was turned over upon his face. Forty-eight hours after the accident, death ensued. There was no autopsy. Paul Belcher[3] relates the case of a sawyer, aged 37, who fell from a cart while drunk. He was stunned and had a scalp-wound. There were pain, paralysis, and priapism. On the next day, crepitus over the first and second dorsal vertebræ was noted. He died fifteen days after the injury. *Dissection* showed fractures of the first and second dorsal vertebræ; a small clot in the spinal canal; the theca vertebralis torn; and the spinal cord diffluent. (Ashhurst.) In this case, intra-spinal hemorrhage arose from the injury, as in Prout's case just mentioned. It seems that a myelitis also arose from the injury, which disorganized the spinal cord and destroyed life.

Simple fractures of the bodies of the vertebræ have been met with most often in the parts of the spinal column which allow the greatest range of motion, to wit, between the third and seventh cervical vertebræ, between the eleventh dorsal and second lumbar, and between the fourth lumbar and the sacrum.

The *direction* of these fractures of the bodies of the vertebræ may be transverse, oblique, or vertical. The oblique and vertical lines of fracture may pass through the bodies of two or three vertebræ successively. Sometimes the lines run in several different directions in the same vertebra, as, for instance, when the fracture is comminuted. The lines of fracture may simultaneously extend through the laminæ or pedicles, as well as through the bodies of the vertebræ. When the direction is oblique, Malgaigne thinks that the fracture always extends from above downward and from behind forward, and constitutes a sort of inclined plane, down which the upper fragment slides, unless it is restrained by the vertebral ligaments. Malgaigne's views on this point are supported by the observations of other surgeons. This is the chief way in which displacement results from fractures through the bodies of the vertebræ.

It is scarcely necessary to say that the displacement arising from *fractures* is quite distinct from that which arises from *luxations* of the bodies of the vertebræ. It is likewise scarcely necessary to say that the displacement arising from fractures may be attended with an overlapping of the lower fragment, caused by the sliding downward and forward of the upper fragment, and that an appreciable shortening of the spinal column may be produced in this manner. When *shortening* of any part of the spinal column is caused by vertebral injury, it affords undoubted evidence, not only that there is fracture, but also that the fracture involves the body of one, or more than one, vertebra at that part. The following example will usefully illustrate this point:—

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[1] American Med. Times, N. S., vol. viii.

[2] American Journ. Med. Sciences, 1837.

[3] British Med. Journal, 1862.

Dr. T. G. Morton[1] reports the case of a young man, aged 19, injured by falling into the hold of a vessel, and striking his head and neck. The neck was shortened, and the head thrown forward. There were pain, paralysis, and priapism, with "symptoms of concussion." In ten days death ensued. *Dissection* showed fractures of the fourth, fifth, and sixth cervical vertebræ; partial dislocation of the fifth; the spinal cord was compressed, and there were blood-clots in the vertebral canal. (Ashhurst.) To the symptoms of fracture of the bodies of the vertebræ already mentioned, *shortening* of the spinal column, when it is caused by vertebral injury, must, therefore be added.

By the displacement of the fragments, which results from certain fractures of the bodies of the vertebræ, the spinal cord may be bruised, compressed, or even severed; and, in this way, *spinal paralysis*, *priapism*, *retention of urine and feces*, *bed-sores*, etc., are not unfrequently produced. But spinal paralysis, appearing coincidently with the accident which causes the fracture, is quite as likely to arise from concussion of the spinal cord as from compression thereof; for fractures of the bodies of the vertebræ are often attended by concussion of the spinal cord—much oftener, I fancy, than luxations. When spinal paralysis begins a few hours after the accident, in the lower extremities, and creeps gradually upward, it is generally due to extravasation of blood within the theca vertebralis. Many examples have already been presented.[2] When spinal paralysis begins at a later period, it is often caused by spinal meningitis or myelitis.[3] But much displacement of the fragments, *without* the occurrence of spinal paralysis, has often been observed in cases where the lower dorsal and the lumbar vertebræ were fractured. For example, Mr. Shaw[4] reports four cases in which the lower dorsal and the upper lumbar vertebræ were fractured, and the fragments much displaced, without causing any spinal paralysis. These patients all recovered more or less completely. It will be remembered that the spinal cord, having progressively diminished in size in the dorsal region, terminates in adults in a rounded point at the first or second lumbar vertebra, after sending off the cauda equina; in children, at birth, it extends to the middle of the third lumbar vertebra, and, in the embryo, is prolonged as far as the coccyx. Dr. Bennett[5] relates a case of fracture of the third lumbar vertebra from direct violence, without the spinal canal suffering from encroachment.

Local *pain*, as already stated, is usually present in cases where the bodies and pedicles, etc., of the vertebræ are broken. But when the spinal nerves also are injured by fracture-splinters, especially during their passage through the intervertebral foramina, severe pain is excited in their terminal branches, which appears to the unfortunate patient to be fixed in the parts supplied by the injured nerves. For instance, when the sixth, seventh, or eighth dorsal nerve is thus irritated at the intervertebral foramen, pain and perhaps cramps, corresponding to the irritation, will be felt in the part of the abdominal walls where the terminal branches of the injured nerve are distributed. The presence of such a pain not unfrequently furnishes important aid in diagnosticating a vertebral fracture.

The symptoms and diagnosis of the so-called *latent fractures* of the bodies of the vertebræ yet remain to be considered. These cases are not attended by appreciable displacement of the fragments during life, nor by crepitus, nor by shortening of the spinal column, nor, at the outset, by spinal paralysis. They bear a close resemblance to instances of sprains or wrenches of the vertebral joints. Like sprains, they are caused by blows on the back, or by falls, etc.

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[1] Proceedings Pathol. Soc. Philadelphia, vol. i.

[2] For a further discussion of these important topics, see Injuries of the Spinal Cord, *infra*.

[3] See Traumatic Meningitis and Traumatic Myelitis, *infra*.

[4] Med. Gazette, vol. xvii., and Trans. Pathol. Soc. London, vol. iii.

[5] Dublin Quart. Journal, February, 1869.

Like sprains or wrenches, they are attended by local pain and tenderness under pressure, by tumefaction, by ecchymosis, and by impaired function of the injured part. There are, however, some important differences: 1. In the cases of spinal fracture the tenderness is usually restricted to one or two vertebræ, whilst in the cases of sprain it is diffused over the joints of several contiguous vertebræ which have suffered almost alike. 2. The functions of the spinal column, as an instrument for mechanically supporting the body, are usually affected to a much greater extent by latent fractures than by sprains. In an instance of the former, which came under my own observation, there was utter inability on the part of the patient to sit upright in a chair or bed without assistance, although there was no paralysis. Had the case been merely a sprain, and not a fracture of the spinal column, the patient would have been able to sit upright, unaided, when placed in a chair or raised up in bed. In a case of Abernethy's, mentioned above, the patient could not raise himself in bed, and there was no reason apparent for this inability until the fracture was revealed by the autopsy. By attending to these two points, then, latent fractures can sometimes be distinguished from sprains or wrenches of the vertebral column.

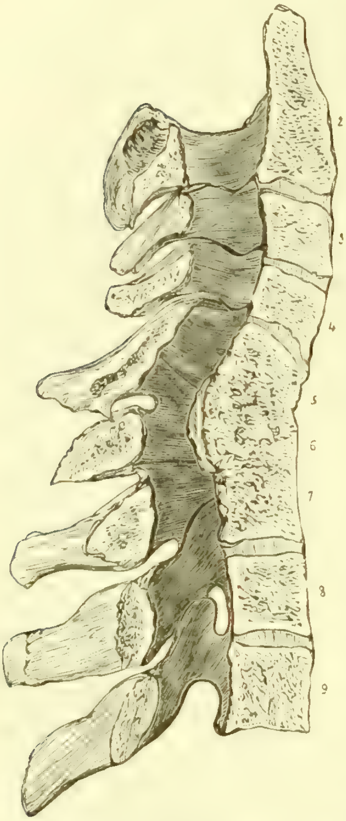
Prognosis.—In cases of vertebral fracture the prognosis is never favorable, unless the lesion chance to be restricted to the spinous processes, as already stated. But fractures occurring in the cervical region are more dangerous than those in the dorsal region, and these in turn are more hazardous than those occurring in the lumbar region. Generally, the nearer the broken vertebra is to the roots of the phrenic nerves, the greater the danger becomes. In like manner, fractures of the lumbar and dorsal vertebræ, attended by displacement of the fragments and injury of the spinal cord, with paraplegia, are less speedily fatal than those of the cervical vertebræ. Moreover, in all parts of the spinal column, fractures of the vertebræ which are not complicated with injury of the spinal cord, are less dangerous than those which are attended by such injury.

The proximate causes of death in fractures of the spinal column, aside from pithing the spinal cord by the odontoid process, or by some fragment of the first three vertebræ, are the following: (1) intra-thecal extravasation of blood; (2) spinal meningitis; (3) ascending myelitis; (4) intra-spinal abscess, that is, an accumulation of purulent matter formed between the theca vertebralis and the bone; and (5) trophic disorders of the paralyzed parts, for example, gluteal eschars or acute bed-sores, with vesical and renal inflammations. These trophic disorders arise quite as much, perhaps even more, from the inflammatory disorganizations of the spinal cord which result from vertebral injuries, than from the traumatic lesions of the cord itself. Now, the gravity of the prognosis is always increased by the appearance of any signs of these various complications or accidents which constitute the proximate causes of death in the cases of vertebral fracture which end badly. Hence, the appearance of spinal paralysis in cases where it did not attend the original injury, or the passage of a partial paralysis into a complete paraplegia, but, particularly, the creeping steadily upward of a spinal paralysis that began in the legs, until the sensibility as well as the voluntary motility is destroyed as far as the nipples, or even the root of the neck, are all signs of extreme danger to life. The persistence of an abnormally high or low degree of body-temperature, and the flushing of the face which results from vaso-motor paralysis, especially if it be combined with dyspnœa, are fatal symptoms, and they likewise denote that the end is nigh. Priapism is an unfavorable symptom, but not always a fatal one.

On the other hand, the prognosis becomes less unfavorable when the symptoms of spinal paralysis grow less strongly marked, when the patient recovers the power to micturate at will and to defecate naturally, when the respiratory movements, after being solely diaphragmatic, are again performed in a normal manner, when the sensibility and power of voluntary motion are seen to be returning to the paralyzed parts in general, etc. These signs, and others like them, are of good omen in all cases of spinal injury.

Fractures of the cervical vertebræ, if attended by symptoms which show that the spinal cord is injured, are almost always fatal. Several illustrative cases, as well as the causes of the great fatality of these lesions, have already been presented and described with sufficient minuteness of detail to answer all practical purposes. Of ten patients with fracture of the five lower cervical vertebræ, whose cases are collected by Professor Hamilton,[1] one survived twenty-four hours, one eleven days, one fifteen weeks and six days, one four months, and only one, whose case I shall presently relate and illustrate with a wood-cut, lived fourteen years. To the sad rule which is thus portrayed there are, however, some notable exceptions on record, for example :—

Fig. 776.



Showing a vertical section of the first nine vertebræ, excepting the atlas, from Mr. Hilton's case, in which there were fractures of the bodies of the fifth, sixth, and seventh cervical vertebræ, and the patient survived for fourteen years. The fractured vertebræ are seen to be consolidated by bone, both at their bodies and at their arches.

Ollivier d'Angers[2] reports the case of a man who injured his neck by falling backward from a wheel, and striking the ground with it. There was paralysis, with mobility about the seventh cervical vertebra. After two months the paralysis began to diminish under general treatment. At the end of three years he was nearly well. (Ashhurst.)

Again, the same author[3] relates the case of a carman, aged 21, injured by falling and striking the back of his neck. There was paralysis, etc. In two and a half months he recovered. Six months after the original accident his neck was broken afresh, by being pushed down while he was taking a long walk. There was sudden paralysis, etc.; and in thirty-four days death ensued. *Dissection* showed that the original injury consisted of fractures of the fourth and fifth cervical vertebræ, the body of the fourth having been broken; and that the callus had been fractured by the second fall. (Ashhurst.) Had there been no second accident, this man (there is but little doubt) would have recovered entirely from the original fractures.

Mr. Hutchinson,[4] likewise, reports two cases, the one being that of a woman and the other that of a man, in which there was fracture of the lower cervical vertebræ, with partial paralysis, and yet both patients recovered.

Mr. Hilton has reported a case, with a wood-cut (Fig. 776), in which there were fractures of the fifth, sixth, and seventh cervical vertebræ, with complete paralysis from the neck downward, and yet the patient survived in a paralyzed condition for fourteen years, ultimately perishing from injury of another part :—John Carter, aged 21, on a Sunday morning in May, 1836, fell from a tree, about forty feet, upon his back, or, more probably, upon his head. He was stunned to unconsciousness, and completely paralyzed up to the neck as to both sensation and voluntary motion. The neck was very stiff, but no irregularity of the vertebræ could be perceived. He was treated by venesection and by cupping the back of the neck, "and, using proper remedies, a capability of moving the head gradually returned." The bladder was paralyzed, and catheterization required. After some weeks, the ability to micturate at will appears to have returned, and he was able to defecate by taking senna. After some weeks, also, "a certain amount of motion was restored to the head and neck, and sensibility to the same extent; but the rest of the body remained perfectly paralyzed and insensible." Many years afterward, it was noted that there was nothing abnormal to be felt about the spine; that no costal movements occurred during respiration; that there was perfect loss of voluntary motion in the lower and upper extremities, with almost perfect loss of sensation in the same; that his bowels were never moved without medicine (senna); and that his urine was very offensive when he caught cold, at other times not so offensive, but always a little so. His urine was acid. He felt a distinct pain in the bowels occasionally, and now and then an aching in the loins. When sick, he vomited with great difficulty. Erections of the penis were frequent, and lasted a quarter of an hour, with slight escape of seminal fluid occasionally. Fourteen years after the original injury, he was upset whilst being dragged about in a little four-wheeled cart by a boy, and, as he could not put out his hands to save himself, he fell to the ground with great violence; this led to some chest affection, which caused death in a few days. A complete autopsy could not be obtained; but the specimen was procured, which is portrayed in the accompanying wood-cut (Fig. 776). In it the bodies and arches of the fifth, sixth, and seventh cervical vertebræ are seen blended together by bone. The body of the sixth vertebra is displaced and projects backward into the spinal canal. The intervertebral substances have disappeared, but their outlines are still marked, and their places occupied by bone. Every one must admire the perfect union which has taken place by new bone; and if nature could have done as well with the spinal cord, this patient might have perfectly recovered.[1]

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[1] Fractures and Dislocations, p. 155.

[2] Traité des Maladies de la Moelle Épinière, t. i.

[3] Ibid.

[4] London Hospital Reports, vol. iii. pp. 347, 348.

Mr. Bryant, likewise, mentions the case of a gentleman, aged 29, whom he saw, November 25, 1870, with complete paralysis of the whole body below the fifth cervical vertebra, caused by a fall upon the neck, who was still alive in 1877, breathing solely by the diaphragm;[2] exactly as the man, whose case Mr. Hilton has reported, did for fourteen years, and until he perished in consequence of another accident.

These examples of recovery from cervical fracture have been presented in order to encourage surgeons to give every possible care and attention to the treatment of cervical injuries attended by paralysis, with the hope of obtaining the same happy result.

Recoveries from fractures of the dorsal and lumbar vertebræ have been recorded in so many instances, that these lesions now are often, perhaps generally, considered to be quite amenable to appropriate treatment. This results in great part from the fact that the spinal cord, in adults, not only ends in a rounded point at the first or second lumbar vertebra, but also becomes, in the lower part of the dorsal region, a leash of nerves, the cords of which are wrapped in a strong fibrous covering; and, for this anatomical reason, being able to freely slide on each other, they glide out of the way of the displaced fragments of broken vertebræ, and thus escape serious damage.

As for successful examples, Mr. Hulke[3] records a very interesting case of recovery from fracture of a dorsal vertebra. Baron Dupuytren[4] gives two cases observed at the Hôtel-Dieu. The first was that of a mason, aged 28, who, by a fall, fractured his spinal column about the tenth dorsal vertebra. Paralysis came on in two days. He was treated by cupping, by rest in bed, etc.; and, in two months, he recovered. The second case was that of a washerwoman, who fell from a second story upon her feet, and then upon her back. The tenth, eleventh, and twelfth dorsal vertebræ projected backward, and her right lower extremity was paralyzed. She was treated by bleeding, by rest in bed, etc.; and, in four months, she recovered.

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[1] Op. cit., pp. 65–67.

[2] Op. cit., pp. 203, 204.

[3] Medical Times and Gazette, February, 1874.

[4] Diseases and Injuries of Bones, Sydenham Society's translation, pp. 356, 357.

Five cases of vertebral fracture in the lower dorsal and lumbar regions, with paralysis, are recorded in the London Hospital Reports.[1] Recovery in every instance was obtained, in from four to six months.

Dr. Lente[2] relates the case of a man, aged 20, injured by falling from a roof upon his buttocks and loins. There was fracture of the third or fourth lumbar vertebra, with paralysis. Bed-sores and exfoliation from the fifth lumbar vertebra followed. Afterward he improved. At the end of four years he could not quite stand alone; but he went about the country as a peddler. Dr. Lente likewise reports another case of the same sort, in which recovery took place, and the man was able to work again.

Professor Agnew[3] mentions a case seen by himself two years before, in which the twelfth dorsal vertebra was fractured, with complete paralysis of the lower extremities. The patient recovered sufficiently to make a sea-voyage, and was still living.

Professor Ashhurst[4] has collected from the Pennsylvania Hospital Record the following instances of fracture of the dorsal or lumbar vertebræ, in each of which a more or less complete recovery occurred: (1) A harness-maker, aged 37, injured his back by falling from a roof. The twelfth dorsal vertebra was fractured, and its spinous process projected backward. He recovered in ninety-four days, though slight deformity and paralysis of the right limb still remained. (2) A sailor, aged 40, was injured by falling upon his back. A dorsal vertebra was fractured, with backward projection. In seventy-seven days he recovered, excepting slight deformity. (3) A seaman, aged 25, was injured by falling from a third story. He was found to have a contusion, a scalp-wound, and pain in the back. After some days, projection of the twelfth dorsal vertebra backward was observed, but no paralysis. In sixty-eight days he recovered, and slight deformity only remained. (4) A laborer, aged 55, fell against a fence. He had contusion of the brain, fractures of the first and second lumbar vertebræ, with backward projection, retention of urine followed by incontinence thereof, and paralysis. At the end of three hundred and thirty-three days the power of motion had become, in some degree, restored, but the deformity remained. (5) A laborer, aged 69, fell from a third story window, and fractured the vertebræ at the dorso-lumbar junction. He recovered in one hundred and twelve days, notwithstanding that the prognosis of his case was complicated by an attack of mania a potu. (6) A laborer, aged 20, fell from a tree, and fractured a vertebra. In seventy-seven days he recovered.

Mr. Syme[5] reports the case of a man, aged 32, who fell, striking on his buttocks, and thus injured his spine. The vertebræ projected at the dorso-lumbar junction; there were also pain and spinal paralysis. On the second day he began to improve; and in forty days he recovered, so as to walk with a cane.

Mr. Stanley[6] had the case of a sawyer, aged 23, who fell twenty-four feet. There were pain and ecchymosis in the back, and a fractured calcaneum. After a week, projection of the twelfth dorsal and first lumbar vertebræ was observed. He recovered in two months. There were no spinal symptoms. (Ashhurst.)

Mr. T. Wakley[7] reported two cases of lumbar fracture, with recovery. The first was that of a man, aged 34, crushed in driving through an archway. There were projection of the second lumbar vertebra and spinal paralysis. In thirteen weeks he was able to walk with a cane. In four and a half months he recovered, and resumed his occupation. The second was that of a carriage-maker, aged 31, who received a blow on the back from a ton-weight. There was projection of the second and third lumbar vertebræ, with pain, and spinal paralysis. He recovered in five and a half months. He walked, but not very well.

Sir Charles Bell[8] relates a case of recovery from fracture of the spine, treated by Mr. Joberns. The patient was a young woman, aged 18, thrown from a second story window on her back. There was great tumefaction over the lower dorsal vertebræ; the spinous processes were crushed, but there was no paralysis; there was a wound over the sacrum. She was treated by rest, etc., and in ten and a half months recovered. She lay for eight months with body bent and legs drawn up; but had regained the erect posture when discharged.

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[1] Vol. iii. pp. 326, 346.

[2] American Journal of the Medical Sciences, October, 1857, p. 361.

[3] Op. cit., vol. i. p. 828.

[4] Op. cit., pp. 108–119.

[5] Edinburgh Medical Journal, vol. xxxvii.

[6] Ormerod, Clinical Collections.

[7] Lancet, 1849.

[8] Op. cit.

Dr. Dorrance[1] relates the case of a cooper, who was struck by a falling tree. There were fracture and backward projection of the eleventh dorsal vertebra, with spinal paralysis. He recovered in one year, and resumed his occupation; but slight deformity remained.

Mr. Shaw[2] reports four cases of vertebral fracture in the dorso-lumbar region, but without paralysis, in which each patient recovered sufficiently to resume work again.

But Mr. Teale[3] has recorded the most interesting case of all. In it the body of the second lumbar vertebra was crushed, and there was spinal paralysis; still, the patient made a complete recovery, but with angular curvature, and survived twelve years in good health, when, having died of typhus, the diagnosis was verified by an autopsy. The patient was an adult man. His injury was caused by a beam falling across his back. When admitted to the infirmary, all the usual signs of vertebral fracture, with displacement, were present in the lumbar region. He was unable to move his legs; and, for three weeks after admission, required the use of a catheter to empty his bladder. Sensation was not wholly lost at any time. At the end of three weeks, he micturated without assistance, and could walk across the floor with the aid of a stick. Six weeks after the accident, he walked well, and was discharged cured. A projection of the spinous process of the first lumbar vertebra had been felt from the first, and was still present when he left the hospital. After twelve years' good health, he was again admitted for typhus fever, of which he died, and then the specimen was obtained. It showed an obtuse bend forward in the upper part of the lumbar region. The body of the second lumbar vertebra had been crushed; and, at the anterior border, had not more than half the normal thickness. Anchylosis had occurred between the first and second lumbar vertebræ.

Some seven or eight additional cases of fracture of the dorsal and lumbar vertebræ, in each of which recovery ensued, will presently be mentioned or referred to under the head of *treatment.*

In France, besides the cases of Dupuytren mentioned above, several successful examples belonging to the same category have been reported, two by Bégin,[4] four by J. Cloquet,[5] and at least one by Malgaigne.[6] In most of these cases there was complete spinal paralysis, but it gradually disappeared; and, after some months, or even years, of treatment, recovery ensued. Many other successful examples of the same sort, if time permitted, could doubtless be collected.

Numerous other cases of vertebral fracture, in the dorsal and lumbar regions, in which the patients survived a long time, notwithstanding that the spinal cord was severed, or that the broken bones were much displaced, might likewise be collected. But few of them, however, will be presented.

Professor Hamilton[7] mentions a case under Mr. Key's care, in which the first lumbar vertebra was fractured. The patient, a boy, survived the accident for one year and two days. *Necroscopy* showed bony union, and the spinal cord completely divided.

Sir A. Cooper[8] gives the case of a man, aged 28, under Mr. Harold's care, with fractures of the first and second lumbar vertebræ caused by a mass of chalk falling upon him. There was spinal paralysis, which affected the bladder and intestines as well as other parts. He died from a slough (bed-sore) on the nates, one year and eleven days after the accident. *Necroscopy* showed union by bone, and the spinal cord nearly severed by a fragment of bone which had pierced the theca vertebralis.

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[1] American Journal of the Medical Sciences, O. S. vol. xvi.

[2] London Med. Gazette, vol. xviii. p. 936; Trans. Patholog. Soc. London, vol. iii. p. 420.

[3] Brit. and For. Medico-Chirurg. Review, October, 1869, and New Syd. Soc. Retrospect, 1869–70, pp. 247, 248.

[4] Œuvres Chirurg., t. ii.

[5] Dictionnaire de Médecine, t. ix.; Maisonnabe, Journal des Difformités, t. i.

[6] Op. cit., t. ii.

[7] Op. cit.

[8] Dislocations and Fractures of Joints.

An instance of dislocation of the first, and fracture of the second lumbar vertebra, in which the patient survived the lesion for three and one-half years, and the specimen from which was exhibited at the Pathological Society of London by Mr. W. Wagstaffe, has already been mentioned above.

Professor Agnew[1] gives, with a wood-cut illustrating the lesion, the case of a young man who was caught at the Kensington Depot, Philadelphia, between the platform and a car, in such a way as to fracture the spinal column in the mid-dorsal region, with comminution; yet, notwithstanding that the spinal cord was completely divided by a permanently displaced vertebra, he survived the accident for six months, and perished at last from sloughing of the nates.

Le Gros Clark[2] relates a very instructive case in which the fourth lumbar vertebra was fractured through both pedicles, while its processes were all comminuted, and its ligaments ruptured, so that the body of this vertebra was dislocated forward and downward, and took up a new position in front of the fifth lumbar vertebra, the upper and lower surfaces of both vertebræ being in the same planes; although the injury was at first attended by complete paraplegia, the sensibility was restored entirely, and the motility partially, in five weeks. Death ensued in the seventh week, in consequence of sloughing or acute bed-sores. A highly suggestive feature of this case is the fact that, notwithstanding the enormous displacement which occurred between the fourth and fifth lumbar vertebræ, the spinal cord was not much injured, and the paraplegia soon passed away.

The following is in the same vein: "In one case," says Mr. Hutchinson, "I found the trunks composing the cauda equina lifted a third of an inch on a bridge of bone, formed by the displacement of a fractured lumbar vertebra; but they were in no degree compressed, and, excepting a little ecchymosis in their pia mater, showed scarcely any trace of injury."[3]

A very practical inference from facts such as these is that, however great the displacement and the paralysis may be in cases of fracture or dislocation of the spinal column, we have no right to assume at the outset, during life, that the spinal cord is irreparably or even severely injured thereby.

These clinical histories and accounts of autopsies have been presented, aside from their general value, with a special intent to show that, in cases of vertebral fracture and dislocation, the surgeon is justly entitled to approach the question as to what their treatment should be, with something more of hope for obtaining a happy issue by appropriate treatment, than most text-books on surgery would seem to encourage.

Treatment of Fractures of the Vertebræ.—The successful management of cases in which the spinal column is fractured, chiefly depends on the following points: (1) On preventing those intra-thecal extravasations of blood which destroy life by compressing the spinal cord. (2) On preventing or subduing spinal meningitis, and abscess between the theca vertebralis and the bone. (3) On preventing or subduing ascending myelitis, and all inflammatory disorganizations of the spinal cord. (4) On conducting the bed-sores, and the vesical and renal inflammations, which are apt to complicate such cases, to a favorable issue.

The victim should be carefully picked up, and carried from the scene of the accident home, or to a hospital, on a stretcher, on one extemporized from a settee or a shutter, etc., or in an ambulance, every precaution being taken against increasing the injury of the spinal cord, that was mentioned while describing the treatment of luxations of the vertebræ, especially if the fracture be seated in the cervical region. The surgeon should make his diagnosis as complete as possible, at his first examination of the case, in order to avoid the doing of harm by moving the patient to make any subsequent examinations. The patient should be placed on a water-bed; but, if it is not practicable to do that, upon a soft, thick hair-mattress. The fractured vertebræ should then be "set," that is, their fragments should be restored to as nearly a normal position as possible: (1) by attending to the patient's posture in bed, for sometimes a *dorsal* or even an *abdominal decubitus* will quite remove the deformity, as well as greatly lessen the patient's sufferings; (2) by employing extension and counter-extension (whenever necessary), made with the hands of skilled assistants, at the same time cöaptating the fragments with the hands; and (3) by applying extension continuously with weights, in cases where there is shortening of the spinal column. The following examples are in point:—

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[1] Op. cit., vol. i. pp. 827, 828.

[2] British Med. Journal, October 3, 1868.

[3] London Hospital Reports, vol. iii. p. 360.

Malgaigne[1] gives the case of a clerk, aged 22, who was treated by himself at the Hôpital des Cliniques, in 1843. The man had fallen from a second story, alighting on his heels and buttocks. Both calcanea were fractured. The spinous process of the twelfth dorsal vertebra was also fractured, and displaced toward the right side. There was paraplegia with great pain in the back on motion, and it was thought that a lumbar vertebra was likewise broken. The patient was treated by rest in bed alone, and the paralysis gradually passed away. When he got up, the displaced spinous process had resumed its proper position.

In some cases of vertebral fracture, the fragments readily subside into a normal position when the patient is confined to bed in *dorsal decubitus*. This doubtless occurred in the example just mentioned. In other instances the deformity has been removed by making the patient *lie on his belly*, and a complete cure has been obtained by making him keep that posture until the fracture has united.

Sir B. Brodie[2] mentions the case of a boy, who was injured in the lower part of the back. There were fracture and displacement of the third and fourth lumbar vertebræ, and spinal paralysis. Attempts at reduction were made, and proved partially successful. After the first month, voluntary motion, as well as sensation, gradually returned. At the end of three or four months the patient was much relieved.

Mr. Higginson[3] mentions a case in which there was fracture, with displacement, of a dorsal vertebra. The patient was treated by extension, and recovery ensued.

Mr. Luke[4] relates the case of a man having fracture of the seventh dorsal vertebra. The displacement was corrected by making extension, and the reduction was accompanied by an audible sound. Erysipelas, however, supervened, and caused death seven days after the accident. At the *autopsy*, the spinal cord was found to be softened and disorganized, and to contain purulent matter.

The fatal issue of this case does not appear to have been in even the least degree due to making extension, and effecting reduction of the displaced fragments of the seventh dorsal vertebra. Moreover, I have not found a record of any case of spinal fracture in which the efforts at reduction proved at all hurtful. But reduction by extension is not to be employed in every instance; certainly not in cases where the deformity can be removed by adjusting the patient's posture in bed. Reduction by extension, however, is allowable when much deformity, and especially shortening, of the spinal column exists; and, likewise, when severe pain arises from the fragments of bone pressing upon the spinal nerves. Bryant has seen several cases in which marked relief has been afforded by this means;[1] and the records of surgery contain many others. When practised with discretion, the reduction of vertebral fractures by extension is undoubtedly a valuable mode of treatment. When the displacement shows a decided tendency to recur, and likewise when there is marked shortening, it will often be advisable to make the extension continuous by means of weights attached to the patient by strips of adhesive plaster, and suspended from the head of the bed, in the manner already described while discussing the treatment of vertebral dislocations.

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[1] Treatise on Fractures, etc., p. 342. Packard's translation.
[2] Medico-Chirurgical Transactions, vol. xx. p. 159.
[3] British Medical Journal, 1862.
[4] Lancet, 1850.

When there is much pain at the seat of fracture, or in the terminal branches of the spinal nerves which issue from the spinal column through the intervertebral foramina at the seat of fracture, opium or morphia must be administered in full doses, and at sufficiently short intervals to subdue the pain and keep it in subjection. Afterward, the patient should be kept moderately under the influence of morphia as a precautionary measure against consecutive spinal meningitis and myelitis, and, by the way, opium or morphia thus administered, is one of the most efficient agents for this purpose in the materia medica.

If, in a few hours after the accident, signs of compression of the spinal cord from extravasation of blood within the theca vertebralis should appear, the fluid extract of ergot should be given in full doses, and at short intervals, and an ice-bag should be applied over the spinal column, with a view to suppress the bleeding.

Efforts to abate the inflammation of the injured structures at the seat of fracture, and thus to prevent the occurrence of consecutive meningitis and myelitis, should be made by abstracting blood with leeches, by applying cold lotions, and by keeping the fractured bones as nearly immovable as possible. The attentive reader, doubtless, has already noted that, in many of the successful cases of spinal fracture related above, blood was abstracted, either generally by venesection or locally by cupping, that cooling lotions were applied to the injured part, and that the patient lay quietly in bed.

Should spinal paralysis begin one, or two, or more days after the accident, or should a pre-existing paralysis then begin to increase or invade new parts, or should any other symptoms denoting the presence of spinal meningitis or myelitis appear, the surgeon should seek to control the inflammation of the membranes and substance of the spinal cord, by administering ergot and potassium iodide in full doses, and by insisting on having perfect rest for the injured parts, if this remedial measure have not already been thoroughly enforced.

Should there be inability to micturate, catherization must be employed morning and evening, and oftener if necessary. Should there be constipation, the bowels must be moved at appropriate intervals by giving senna, and by administering enemata. The alimentation of the patient must be attended to, and a nourishing but easily digestible diet allowed. Every possible precaution, in the way of cleanliness, etc., should be taken against the formation of bed-sores.

In regard to the use of mechanical contrivances to keep the broken parts of the spinal column in apposition, and free from all motion, thus performing the offices that splints do in fractures of the extremities, it is obvious that if these ends could be accomplished by any mechanical contrivance, the patient's recovery would be considerably expedited, and the risk of consecutive meningitis and myelitis would be considerably lessened by employing it. As such an apparatus, the plaster-of-Paris jacket, devised by Professor Sayre, has recently been applied in a number of instances. Professor König, of Göttingen, has an article in No. 7 of the *Centralblatt für Chirurgie*, for 1880, on the application of the "Thorax Gypsverband" for fractures of the spine, and recounts therein three cases, in all of which there was considerable displacement, with but very slight, if any, nervous symptoms. In each of these three cases, the patient was suspended sufficiently to correct the deformity, and a long jacket reaching down to the trochanters was put on; and every one of them made a complete and rapid recovery. The cases were all recent and simple. Dr. W. Wagner, however, reports two similar cases in which, after the application of the jacket, intense pain in one instance, and paralysis in the other, appeared in the lower extremities, so that it was necessary to remove the apparatus. In one case it was reapplied subsequently, with comfort to the patient. Both patients recovered.[1] Possibly, the failure of the first application of the jackets, in the last two instances, was due to not exactly reducing the displacement of the fragments prior to fitting the jackets, so that the apparent want of success was caused not so much by the apparatus itself, as by the failure to apply it properly. At all events, no great harm was done, for recovery was not prevented in either instance. Obviously, this plan of treatment is not appropriate for cases in which there are bed-sores, or in which inflammatory disorganization of the spinal cord is already far advanced. But, for simple, uncomplicated cases of spinal fracture, in which the injury is recent, it seems likely to prove of great service, and undoubtedly is in improvement on any of the old methods of treatment now in vogue for such cases.

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[1] Op. cit., p. 204.

When the body-temperature rises to 102° F., or more, and persists, what is to be done? Possibly, in cases where the mercury stands at 102° or 103°, the trunk and extremities may be sponged with diluted alcohol, from time to time, with advantage; and, in cases where it rises to 105°, or more, and the extinction of life is threatened by the body-heat itself, it may be advisable to use the "cold-water pack," carefully noting its effects, meanwhile.

When the body-temperature sinks below the normal limit, whether the coldness be confined to the paralyzed parts or diffused over the whole system, care must be taken in applying artificial heat—*e. g.*, bottles of hot-water, heated bricks, or sad-irons, etc.—lest the parts to which they are applied become burned from the negligence of the attendants.

GUNSHOT INJURIES OF THE VERTEBRÆ.

Soldiers are sometimes killed in battle by gunshot injuries of the cervical vertebræ. Dr. Otis[2] reports two instances of this sort that he had himself seen, in which "the ball lodged in the cervical spine," among the bodies of those lying dead on the field of battle before New Berne. Gunshot injuries of the spinal column may thus quickly destroy life: (1) By dividing or crushing the spinal cord above the third cervical vertebra, that is, above the roots of the phrenic nerves, thereby completely and instantaneously arresting the respiratory movements; and (2) By opening the vertebral artery, in some part of its course within the canal formed by the vertebral foramina in the transverse processes of the six upper cervical vertebræ.

Mr. Shaw[3] has placed on record, together with a wood-cut, the following example, which admirably illustrates the first of these two modes in which gunshot lesions of the spinal column may destroy life with great suddenness:—

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[1] Medical Times and Gazette, December 18, 1880.

[2] Medical and Surgical History of the War of the Rebellion, First Surgical Volume, p. 603.

[3] Holmes's System of Surgery, vol. ii. p. 395.

A gentleman was wounded by a pistol-shot in the back of his neck while lying asleep on his side; his mistress, who was awake at the time, stated that he did not stir a limb nor move in any way, although the report was loud. Death, therefore, must have been instantaneous. *Necroscopy* showed that the missile entered at the median line, passed horizontally forward between the arches of the atlas and the axis, severed the spinal cord, and stuck fast in the odontoid process near its base, having fissured the same. The specimen is preserved in the museum of Middlesex Hospital.

In regard to the second of these two modes in which life may be suddenly destroyed, it should be stated that gunshot fractures, involving any of those transverse processes of the cervical vertebræ through whose foramina the vertebral artery runs, may readily lay the artery widely open, and that the primary hemorrhage therefrom would soon prove fatal; certainly, death would ordinarily ensue before a man thus wounded could be removed from a field of battle. In this connection it may be well to state also that gunshot fractures of these transverse processes are not unfrequently attended by *secondary hemorrhage* of a fatal character, which usually appears some ten or twelve days after the casualty has occurred.

For instance, Baron Dupuytren[1] mentions the case of a carpenter, aged 31, who received a gunshot wound of the face and neck. The ball entered his nose. The wound did well for ten days, when secondary hemorrhage set in, and caused death. *Necroscopy* showed that a transverse process of the second cervical vertebra was fractured, and that the hemorrhage arose from the corresponding vertebral artery.

Usually, in such cases, the laying open of the artery, so that the blood may issue therefrom, is caused either by the separation of a slough consisting of the tissues which have been bruised by the missile in its passage, or by the perforation of the arterial tunics by an ulcerative process. In the following instance, however, it was caused by the beating of the vertebral artery itself against a sharp fragment of the transverse process which had been fractured:—

Samuel S. was wounded at the battle of Williamsburg, May 5, 1862, by a musket-ball which entered his face to the left of the symphysis of the inferior maxilla, smashed that bone, and carried away several teeth, with a part of the tongue and of the posterior wall of the pharynx, and lodged. He had extreme dysphagia. On the 13th, the ball and several teeth were removed from an abscess above the clavicle. On the 16th, copious hemorrhage from the original wound occurred, which was arrested by tying the common carotid artery under ether. Seven days after that, a fresh hemorrhage set in from the aperture through which the missile had been extracted; an unsuccessful attempt was made to find the bleeding vessel. He died on the same day (May 23) of anæmic exhaustion resulting from the hemorrhage. *Necroscopy* showed that a transverse process of the third cervical vertebra had been fractured by the ball, and that the vertebral artery had rubbed against a spiculum thus produced until it was worn through; hence the secondary hemorrhage arose.[2] The first hemorrhage, doubtless, sprang from some branch of the external carotid artery in the face, mouth, or throat, which had been injured by the missile, and, therefore, it was possible to suppress it by ligaturing the common carotid artery.

GUNSHOT CONTUSIONS OF THE SPINAL COLUMN were, I believe, first mentioned by Dr. Louis Stromeyer, while writing from his experience as surgeon-in-chief of the Schleswig-Holstein army, in 1849. He says:—

"In two cases the cervical vertebræ were contused by bullets which entered on the outer side of the sterno-mastoid muscle, and likewise bruised the brachial plexus of nerves; the paralysis of the corresponding arm was at first so complete that I considered the brachial plexus must have been torn by the bullet; but, gradually, sensation and motion almost fully returned.

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[1] Op. cit.

[2] Medical and Surgical History of the War of the Rebellion, First Surgical Volume, p. 355.

"In a case of contusion of the cervical vertebræ by a similar shot, there has remained till this moment—a period of four months—stiffness and pain in the neck on motion. In all these cases small sequestra escaped."[1]

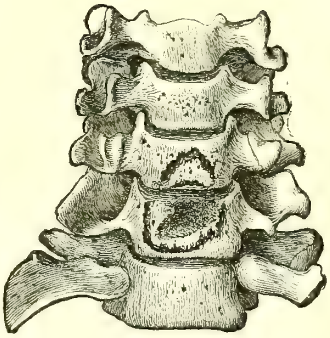
In cases where the vertebræ are contused by gunshot missiles, the bodies are the portions thereof which are usually found to be affected. Indeed, I am not acquainted with any instance where this lesion was confined to the vertebral apophyses.

The consequences of gunshot contusions of the vertebræ are: 1, *necrosis* of the bruised parts; 2, *caries* of the same; and 3, *inflammation* of the injured bone, which may spread to the membranes and substance of the spinal cord.

1. As examples of necrosis, Stromeyer's three cases just mentioned above, in each of which small sequestra escaped from the wound, may be appropriately cited.

2. As an instance of caries arising from this cause, the following abstract, together with the accompanying wood-cut (Fig. 777), may be presented:—

Fig. 777



Showing caries of the last two cervical vertebræ caused by gunshot contusion. (Spec. 1867, Sec. I, A. M. M.)

Private George A. A., 20th New York Volunteers, aged 40, was wounded at Gettysburg, July 2, 1863, by a conoidal ball, which fractured the right lower jaw, struck the bodies of the sixth and seventh cervical vertebræ, and lodged. It is said that the missile was afterward ejected by the patient from his mouth. But pyæmia supervened and caused death. It is stated that the patient had dyspnœa, but no paralysis; that he walked about until a few days before his death, which occurred on the 21st (nineteen days after the casualty occurred); that he had complained only of a slightly uneasy feeling in the neck when turning his head; and that the injury of the cervical vertebræ was not suspected during life. *Necroscopy* showed that the bodies of the sixth and seventh cervical vertebræ were carious in the parts where they had been struck and bruised by the missile (see Fig. 777), and that a fissured fracture extended through the body of the sixth vertebra. Pyæmic lesions, too, were found; that is, the right lung was in a condition of recent pneumonia, and filled with a multitude of small abscesses, the presence of which fully accounted for the occurrence of dyspnœa. The œsophagus, the trachea, and the bronchial mucous membrane were inflamed.[2] In this case, the contusion of the cortex or outer lamella of the body of the sixth cervical vertebra was complicated by a fissured fracture of the vertebral body; the body of the seventh cervical vertebra, however, was not fractured, but only bruised and carious. The carious condition of both vertebræ is well shown in Fig. 777. The specimen which it represents is preserved in the Army Medical Museum.

3. The spreading of inflammation from the injured bone to the membranes and substances of the spinal cord, with a fatal result in consequence thereof, may be illustrated in a useful manner by presenting another example taken from Stromeyer:—

"In a case where a bullet, entering laterally, severely bruised the third and fourth cervical vertebræ, and was not extracted, death followed in consequence of the advance of inflammation into the spinal cord and brain; there was at first palsy of the arm belonging to the injured side; it was followed by incomplete paralysis of all the limbs, ending in stupor. Antiphlogistic treatment had been entirely neglected."[1]

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[1] Stromeyer on Gunshot Fractures, translated by S. F. Statham, pp. 37, 38. Am. ed.

[2] Medical and Surgical History of the War of the Rebellion, First Surgical Vol., p. 431.

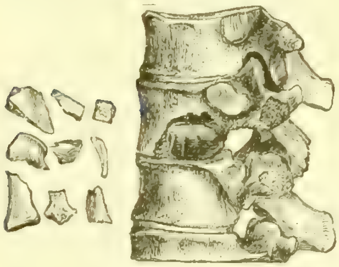
Etiology.—The impact of gunshot missiles upon the bodies of the vertebræ causes contusion thereof only when the force of the missiles is nearly spent, on the one hand, or when the direction of their flight is very oblique, so that they strike a glancing blow, on the other hand. When endowed with less force, they do no injury; and with greater force they produce fractures.

Treatment.—The principal indication in the therapeusis of gunshot contusions of the spinal column is to prevent the occurrence of inflammation in the injured bone, and the spread of the inflammatory process therefrom to the meninges and medulla spinalis. This can best be accomplished by the extraction of all foreign bodies from the wounds, by the employment of antiseptic dressings, by thorough drainage by means of appropriate tubes, inserted for the purpose whenever necessary to prevent the collection of purulent secretions, and by enforcing perfect rest of the injured spinal column.

GUNSHOT FRACTURES OF THE VERTEBRÆ are caused by the impact of shell-fragments, spent cannon-balls, and small-arm missiles, but chiefly by the impact of the last named, after they have penetrated the integuments and other structures that cover the spinal column at the place of injury, or have reached it by passing through the great cavities of the body and organs which lie in front. In some rare instances, however, the fractures produced by cannon-balls and shell-fragments are simple, the integuments covering them being unbroken. Gunshot fractures of the vertebræ are usually comminuted in character as well as compound; and they are very often complicated with injury of the spinal cord and other important organs.

For descriptive purposes, gunshot fractures of the vertebræ may advantageously be divided into two classes—namely, those which are restricted to the apophyses, and those which involve the vertebral bodies also. The former are sometimes, perhaps frequently, unattended by injury of the spinal cord; the latter are but seldom uncomplicated with such injury. The former, too, are less fatal, as a rule, than the latter.

Fig. 778.



Showing a gunshot fracture of the body and left transverse process of the ninth dorsal vertebra. The missile and nine fragments of bone are also shown. (Spec. 5738, Sect. I, A. M. M.)

The chief characteristics pertaining to gunshot fractures of the spinal column, in general, are well shown by the following abstract, and by the wood-cut (Fig. 778) which accompanies it:—

A soldier was wounded by a conoidal pistol-ball (calibre 44), which entered one and a half inches below and a little to the inner side of the left nipple, passed backward, grazing the apex of the heart, through the left lung, and onward through the body and left transverse process of the ninth dorsal vertebra; it lodged in the subcutaneous tissue of the back, from which it was extracted, together with some small fragments of bone, through a small incision. The patient was paralyzed below the middle. He died of traumatic pericarditis and pneumonia, four days after the wound was inflicted.[2] The deep groove across the spinal column which was punched out by the missile, and the comminution of the injured bone, are well depicted. The occurrence of paraplegia, of course, denotes that the spinal cord was also injured.

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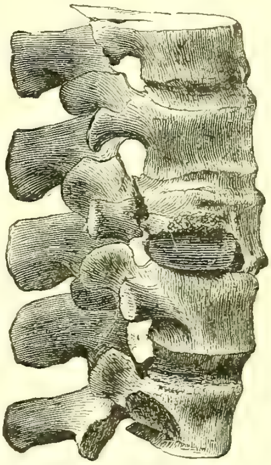
[1] Op. cit., p. 38.

[2] Circular No. 3, S. G. O., August 17, 1871.

Sometimes the missile punches a ragged hole through the vertebral column obliquely from behind forward, and emerges from the body of a vertebra, having crushed the spinal cord in its course; as, for instance, it did in a specimen which the writer contributed to the Army Medical Museum, and which is represented by the annexed wood-cut (Fig. 779):

The missile entered through the left intervertebral foramen between the third and fourth lumbar vertebræ, chipping the superior articular process of the fifth and the adjacent portion of the spinous process of the fourth, and fracturing the left transverse process of the fourth, passed obliquely forward and toward the right, and emerged from the body of the third lumbar vertebra on its right side. The patient survived long enough for incipient caries to appear in the injured bones.[1]

Fig. 779.

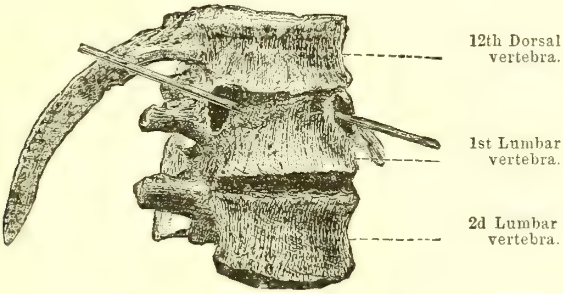


Showing gunshot fracture of the third lumbar vertebra with the missile (a conoidal musket-ball) attached. (Spec. 2532, Sect. I, A. M. M.)

In the celebrated and historical case of President Garfield, the ball penetrated the first lumbar vertebra in the upper part of the right side of its body (Fig. 780):—

The aperture by which it entered involved the intervertebral cartilage next above, and was situated just below and anterior to the intervertebral foramen, from which its upper margin was about one-fourth of an inch distant. Passing obliquely to the left and forward through the upper part of the body of the first lumbar vertebra, the bullet emerged by an aperture, the centre of which was about half an inch to the left of the median line, and which also involved the intervertebral cartilage next above (Fig. 017).

Fig. 780.



Showing the hole made by the missile (a conoidal pistol-ball) through the body of the first lumbar vertebra, in the case of President Garfield. A probe penetrates each orifice. $\frac{2}{3}$.

The cancellated tissue of the body of the first lumbar vertebra was very much comminuted, and the fragments were very much displaced. Several deep fissures extended from the track of the bullet upward into the lower part of the body of the twelfth dorsal vertebra. Others extended downward through the first lumbar vertebra into the intervertebral cartilage between it and the second lumbar vertebra. Both this cartilage and that next above were partly destroyed by ulceration. A number of minute fragments from the fractured lumbar vertebra were driven into the adjacent soft parts. On sawing through the vertebræ from behind, a little to the right of the median line (Fig. 781), it was found that the spinal canal was not involved by the track of the missile. The spinal cord and other contents of the spinal canal presented no abnormal appearance. The fractured spongy tissue of the vertebræ was suppurating. The missile was lodged behind the pancreas. Secondary hemorrhage from the splenic artery had supervened, causing death seventy-eight days after the infliction of the wound.[1]

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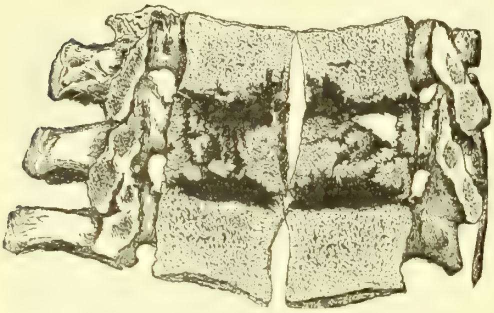
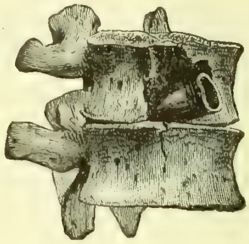
[1] Medical and Surgical History of the War of the Rebellion, First Surgical Volume, p. 446.

Fig. 781.



Interior view of the last dorsal and first two lumbar vertebræ, in the case of President Garfield. They have been laid open from behind by sawing vertically through their laminæ and bodies, a little to the right of their spinous processes. The intervertebral substances have been destroyed by the inflammatory process. The cancellated tissue of the bodies is extensively disorganized by suppurative osteomyelitis, as well as by the impact of the missile. $\frac{2}{3}$.

Fig. 782.



Showing two lumbar vertebræ that were perforated from behind forward, and were fissured vertically, through their bodies, by a conoidal musket-ball which passed into the peritoneal cavity. (Spec. 3583, Sect. I, A. M. M.)

In the case of President Garfield, the shot fractures of the last dorsal and first two lumbar vertebræ were followed by suppurative osteo-myelitis and destruction by ulceration of the corresponding intervertebral disks, from which disorders arose the symptoms of septicæmia that presented themselves at one time in the history of his case, and, finally, the secondary hemorrhage that destroyed his life. The prognosis in cases of suppurative osteo-myelitis arising from vertebral fractures is always very bad; in fact, such cases are scarcely amenable to any treatment.

In the following example, a conoidal musket-ball penetrated the lumbar portion of the spinal column from behind, passed forward through the bodies of the vertebræ, having crushed the spinal cord, and entered the abdominal cavity, where it wounded the liver, and likewise caused peritonitis, which proved fatal in four days:—

A corporal, having been wounded in front of Petersburg, on July 30, 1864, was sent to Washington, and admitted to Douglas Hospital, on August 3, with complete paraplegia and peritonitis. He died on the same day. *Necroscopy* revealed the passage of the missile into the abdominal cavity through the spinal column, and laceration of the liver, with peritoneal inflammation and the products thereof. The fractured vertebræ and the missile are represented in the adjoining wood-cut (Fig. 782).[2]

Small-arm missiles, as, for instance, musket and pistol balls, etc., often lodge in the bodies or apophyses of the vertebræ, in such a manner that either their position cannot be exactly ascertained, or they cannot be extracted in consequence of the firmness of their impaction. This important class of spinal injuries will be illustrated in a useful manner by the next half dozen abstracts and wood-cuts:—

A soldier, aged 20, was wounded in the back at Monocacy, Md., July 9, 1864, and admitted to hospital at Frederick, on the next day. The missile (a conoidal musket-ball)

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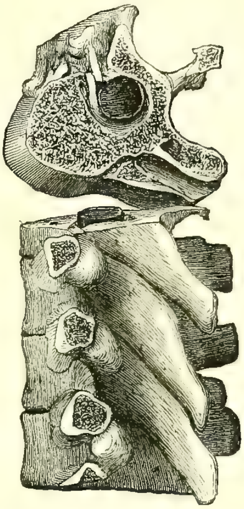
[1] American Journal of the Medical Sciences, October, 1881, pp. 586–590.

[2] Medical and Surgical History of the War of the Rebellion, First Surgical Volume, p. 444.

Fig. 783.



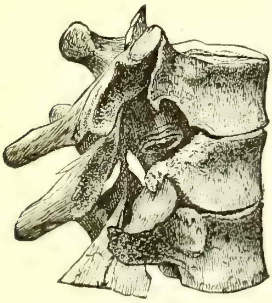
Showing the fifth, sixth, seventh, and eighth dorsal vertebræ, with the body, etc., of the fifth horizontally divided, and a conoidal musket-ball (also divided) lodged in the spinal canal. (Spec. 3984, Sect. I, A. M. M.)

had entered at the inferior border of the left scapula, passed inward and backward, struck the spinal column, and lodged, having instantaneously caused complete paraplegia below the wound, with inability to micturate. On the 12th, the urine began to dribble away spontaneously, and defecation occurred involuntarily. He made no complaint of pain. Bed-sores over the sacrum, etc., depending upon the mal-nutrition of the parts which resulted from the injury of the spinal cord, soon followed. Nevertheless, he survived until October 13, and then died of pleuro-pneumonia. *Necroscopy* showed that the missile had passed through the left intervertebral foramen between the ninth and tenth dorsal vertebræ, producing only a very slight fracture; and, turning upward in the spinal canal, had lodged in it opposite the body of the fifth dorsal vertebra. The upper end of the spinal cord was much softened. The lodgment of the missile is well shown in the adjoining wood-cut (Fig. 783).[1]

A soldier, aged 26, was wounded at Cold Harbor, Va., June 3, 1864, by a conoidal musket-ball, which penetrated the right side of his back, shattered the right transverse and articular processes of the eighth and ninth dorsal vertebræ, and entered the spinal canal. He immediately lost all sensation and voluntary motion below the wound. On the 11th, he was admitted to general hospital. There was then psychical depression, with slow pulse, labored respiration, cold, clammy, and cyanosed skin, and involuntary passage of the excretions. Gastric irritability supervened, with rejection of all kinds of nourishment, and he died on July 2. *Necroscopy* revealed the missile imbedded in the spinal canal, as shown in Fig. 784. The spinal cord was severed and disorganized above and below the missile.[2]

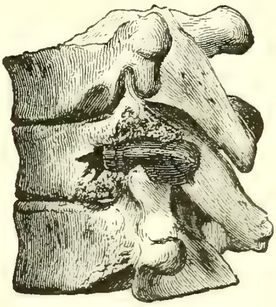
Corporal G. W. M., aged 19, was wounded at Cold Harbor, Va., June 3, 1864, and admitted to general hospital on the 7th. He was suffering from paraplegia with retention of urine and traumatic pneumonia. A conoidal musket-ball had entered his back near the inferior angle of the left scapula, and passing downward, inward, and forward through the left lung, had fractured the transverse process of the seventh dorsal vertebra, and lodged in the body of the same. Owing to his extreme prostration, no anti-

Fig. 784.



Showing a conoidal musket-ball lodged in the spinal canal between the eighth and ninth dorsal vertebræ. (Spec. 2939, Sect. I, A. M. M.)

Fig. 785.



Showing gunshot fracture of the left transverse process and body of the seventh dorsal vertebra, with the missile *in situ*. (Spec. 3030, Sect. I, A. M. M.)

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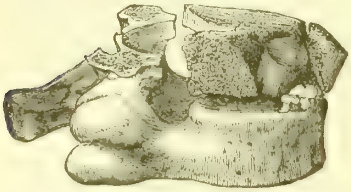
[1] Medical and Surgical History of the War of the Rebellion, First Surgical Vol., p. 440.
[2] Ibid., p. 439.

phlogistic measures of an active character were employed. Stimulating frictions were frequently applied to the legs and hips, and the chest was enveloped in an oil-skin jacket. He died on the 19th. *Necroscopy.*—The ball was found imbedded in the body of the seventh dorsal vertebra, encroaching upon the medulla spinalis, as represented in the accompanying wood-cut (Fig. 785). The lungs were hepatized at their bases; and, near their apices, were filled with a dark, frothy liquid.[1]

A colored soldier, aged about 25, was wounded at Brownsville, Texas, January 28, 1866, by a pistol-shot, and died in thirty-eight hours, from shock and internal hemorrhage. *Necroscopy* showed that the missile had entered two inches below and outside of the left nipple, gouged its calibre from the upper border of the eighth rib, passed downward, inward, and backward, through the lower lobe of the right lung, the diaphragm, and the right lobe of the liver, and had lodged in the body of the last dorsal vertebra, fracturing it as shown in the adjoining wood-cut (Fig. 786), which represents the specimen now preserved in the Army Medical Museum.[2]

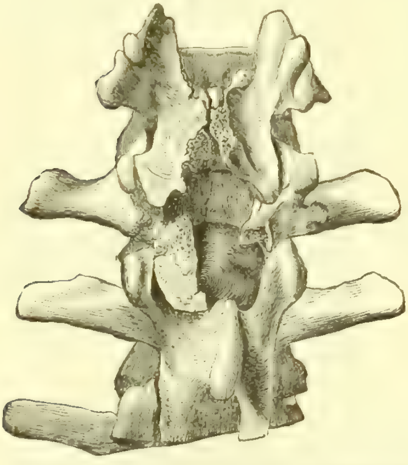
Fig. 786.



Showing a pistol-ball (calibre 37) lodged in the body of the last dorsal vertebra, having fractured the same with much comminution. (Spec. 3780, Sect. I, A. M. M.)

A quartermaster's sergeant, aged 36, was wounded at Compton, La., April 4, 1864, by a grape-shot, which entered his loins one inch to the right of the spinous processes, and about two inches below the last rib, and, passing forward and slightly downward and inward, struck the spinal column, and, lodging, was not extracted. On the 10th he was admitted into University Hospital, at New Orleans. There was no paralysis. The symptoms of pyæmia, however, supervened, and he died of that disease on the 18th. *Necroscopy* revealed a round iron ball, about one inch in diameter, lodged on the left psoas magnus muscle. The spinous processes and laminæ of the last dorsal and first lumbar vertebræ were fractured and displaced, and thus the spinal canal was laid open. The specimen is represented by the accompanying wood-cut (Fig. 787). Purulent infiltration was found in the psoas muscles, with their investments, and in the peritoneal cavity. Two small circumscribed metastatic abscesses were found in the right lobe of the liver. There were no signs of paralysis present during life.[3]

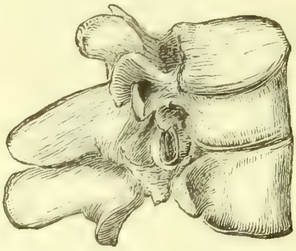
Fig. 787.



Showing fractures of the spinous processes and laminæ of the last dorsal and first lumbar vertebræ, caused by a round iron ball about one inch in diameter. (Spec. 3739, Sect. I, A. M. M.)

A sergeant of infantry was wounded at Opequon Creek, near Winchester, Va., September 19, 1864, by a conoidal musket-ball, which penetrated the lumbar region through the erector-spinæ muscles, a few inches above the posterior crest of the ilium, and lodged.

Fig. 788.



Showing a conoidal musket-ball imbedded in the intervertebral substance between the third and fourth lumbar vertebræ. (Spec. 3796, Sect. I, A. M. M.)

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[1] Med. and Surg. History of the War of the Rebellion, First Surgical Vol., p. 438.
[2] Ibid., p. 441.
[3] Ibid., p. 443.

The left ankle and lower third of the femur were shattered, for which amputation of the thigh was performed. The only symptom, indicating that the spinal cord or spinal nerves were injured, was paralysis of the right leg. *Necroscopy.*—The missile was found imbedded in the intervertebral substance between the third and fourth lumbar vertebræ, as shown in the adjacent wood-cut (Fig. 788), which represents the specimen. There was very little pus in the wound.[1]

Prognosis.—Gunshot lesions of the spinal column are very serious injuries. They proved fatal in more than one-half of the instances which came under treatment during our late civil war; and many who sustained such injuries must have perished on the field before any treatment could be adopted.

Six hundred and forty-two cases of gunshot injury of the vertebræ were reported by our military surgeons during the late civil war. Of these, three hundred and forty-nine, or 55.5 per cent., proved fatal; one hundred and seventy-five soldiers were discharged from the service; one hundred and four were returned to duty; while, in fourteen instances, the result is not known. Again, of these six hundred and forty-two cases, the cervical vertebræ were injured in ninety-one, with a mortality of sixty-three, or 70 per cent.; the dorsal vertebræ, in one hundred and thirty-seven, with a mortality of eighty-seven, or 63.5 per cent.; the lumbar vertebræ, in one hundred and forty-nine, with a mortality of sixty-six, or 45.5 per cent.; the cervical and dorsal, in two instances, of which one proved fatal; and the dorsal and lumbar, in three instances, which all proved fatal. In two hundred and sixty cases, where the injured vertebræ were not specified, one hundred and twenty-nine, or 49.4 per cent., proved fatal.

The percentage of mortality above stated is, for vertebral injuries in the cervical region, 70, for those in the dorsal region, 63.5, and for those in the lumbar region, 45.5. Other things being equal, the prognosis is less unfavorable in cases where the dorsal vertebræ are wounded by gunshot missiles, than it is in cases where the cervical vertebræ are injured in this manner; and, in cases where the lumbar vertebræ are affected, it is much less unfavorable than it is in cases where the dorsal vertebræ are involved, and very much less unfavorable than it is in cases where the cervical vertebræ are injured.

Gunshot fractures of the cervical vertebræ, when attended by complete paraplegia, are almost always fatal; and, generally, death occurs before the fourth day in such cases. I had under my care at the battle of Fair Oaks, May 31 and June 1, 1862, two cases in which there were fractures of the lower cervical vertebræ caused by musket-balls.

In both cases, the upper as well as the lower extremities, and all the parts and organs that were supplied with spinal nerves which issued from the spinal column at or below the seat of the lesions, were completely paralyzed in respect to both sensation and voluntary motion. There was retention of urine and feces, and catheterization had to be resorted to. The respiration was entirely diaphragmatic, for all the respiratory nerves, excepting the phrenic, were paralyzed. The inferior margin of the thorax was also drawn inward, whenever the diaphragm contracted, thus reducing the antero-posterior and lateral diameters of the chest, as well as increasing the vertical diameter thereof, at the end of every movement of inspiration. The muscular wall of the abdomen was relaxed and flaccid till tympanites supervened, which added much to the respiratory embarrassment. Both patients died asphyxiated; one of them on the third, and the other on the fourth day after the injury was inflicted. The intellect was clear in both cases, and there were no head-symptoms whatever, until the stupor of asphyxia approaching a fatal termination appeared. No autopsies were held, from want of time to make them.

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[1] Ibid., p. 450.

A. M. Soteldo was wounded, on Thursday night, February 9, 1882, at the editorial rooms of a Washington newspaper, by a cylindro-conoidal pistol-ball, which entered the back of his neck four inches below the occipital protuberance and slightly to the left of the median line, passed forward and slightly upward, fractured the lamina of the fourth cervical vertebra a little to the left of the spinous process thereof, penetrated the spinal dura mater (theca vertebralis), and imbedded itself in the left intervertebral foramen between the fourth and fifth cervical vertebræ, having bruised and slightly lacerated the spinal cord, and driven into its substance a small splinter of bone. He immediately became "paralyzed from the head down," that is, all of his extremities and the whole of his body below the neck, were completely deprived of sensibility and voluntary motility. The respiratory movements were performed by the diaphragm alone. He died at 10 h. 25 m. on the night of Saturday, the 11th, about forty-eight hours after the casualty occurred. The *autopsy* revealed the course and place of lodgment of the missile, and the injuries done by it, which have just been described. The missile weighed, after extraction, eighty-seven grains.

There is, however, recorded in the first surgical volume of the Medical and Surgical History of the late Civil War, at page 430, a case of gunshot fracture of the body of the third cervical vertebra, with lodgment of the missile and complete paraplegia, in which recovery was secured by persevering treatment. A brief abstract of this case should be presented in this place, because it will encourage surgeons to give more attentive treatment to such cases, by showing that they are not always hopeless:—

An infantry soldier, aged 20, was wounded at Gettysburg, July 2, 1863, by a conoidal ball, which entered the right upper lip at the second incisor, destroyed all the teeth save the last molar, on the same side of the upper jaw, passed below the soft palate into the pharynx, and penetrated the body of the third cervical vertebra, where it lodged and was not extracted. But in the following August, the position of the ball was ascertained by a Nélaton's probe, and it was then extracted. "There was paralysis in all four limbs, from which, however, he rapidly recovered; and, for a time, did duty as hospital attendant." On March 14, 1864, this patient was transferred to Turner's Lane Hospital, at Philadelphia. Acting Assistant-Surgeon W. W. Keen, Jr., on duty at that hospital, states that "nearly the entire body of the third cervical vertebra has come away, including the anterior half of the transverse process and the vertebral foramen. No injury to the vertebral artery has been disclosed. What supports his head anteriorly I cannot conceive. On May 3, he was transferred to Washington to be assigned to a company in the Veteran Reserve Corps. The only remnant of his paralysis is some [loss] of sensation over a surface, say three by four inches, at the back of right neck. Some bone still is occasionally discharged." In April, 1871, this man was yet alive; and the pension-examiner reports that the right side of his tongue is distorted, leaving his speech affected; that the right side of his throat is contracted; and that his right shoulder and arm are diminished in size and partially paralyzed. Disability three-fourths and permanent.

But gunshot fractures of the spinal column, and particularly those in the cervical and upper dorsal regions thereof, are generally mortal, unless the lesions be confined to their apophyses.[1] In the Schleswig-Holstein campaign of 1849, Stromeyer observed that "injuries of the spinous processes frequently occurred without serious consequences—without accidents from concussion of the spinal marrow."[2] During the late civil war I saw a considerable number of cases in which the spinous processes alone had been broken off by the impact of small-arm missiles, without any apparent fissuring of the laminæ or bodies, etc., of the injured vertebræ, and without any serious lesion of the spinal cord. These patients all recovered.[1] In some of these cases, spinal paralysis, too, was present at the outset, but it probably arose from concussion of the spinal cord, for it soon passed away. Professor Ashhurst[2] mentions, in point, the case of a soldier, seen by himself, who was wounded by a musket-ball in the lumbar region. The missile entered to the left side of the spinal column, carried away the spinous process of a lumbar vertebra, and lodged; it was extracted from the right hip many months afterward. At first there was spinal paralysis. This soldier recovered and was transferred to the Veteran Reserve Corps. Nearly two years subsequent to the casualty his back was yet stiff, and occasionally painful. Most of the 104 patients having gunshot lesions of the spinal column, who recovered and were returned to duty in our army during the late civil war, doubtless sustained merely fractures of the spinous or transverse processes. Indeed, the abstracts of the successful cases belonging to this category, which are presented in the surgical history of the war, strongly support this view. It is, therefore, but reasonable to conclude, that in cases of gunshot fracture of the vertebræ, the prognosis is very much less unfavorable when the lesion is restricted to the spinous or transverse processes, than when other parts are involved.

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[1] In the British army, during the Crimean war, "all the fractures of the vertebræ were promptly fatal, except two among the officers and two among the men, all of which were either fractures of the transverse processes in the neck, or of the spinous processes only." (Medical and Surgical History of the British Army in the War in the Crimea, etc., vol. ii. p. 337.) Thus it appears that the only cases of shot fractures of the vertebræ which terminated in recovery among the British soldiers and officers wounded in the Crimean war, were those in which the lesions were restricted to the spinous and transverse processes.

[2] Op. cit., p. 37.

A few, however, of the one hundred and four patients having gunshot fractures of the vertebræ got more or less completely well again, when the bodies, or the laminæ, or the vertebral pedicles were broken, and when the spinal cord was at the same time considerably injured. For, "in fifty-four cases of gunshot injury of the vertebræ, complicated by traumatic lesions of the cord, forty-two were fatal, and twelve partially recovered and were discharged, with various degrees of physical disability. The cases of contusion and commotion of the spinal cord are not included in this category."[3] Some, at least, of those who were returned to duty must have been affected with contusion and commotion of the spinal cord, and with lesions of the vertebræ more severe than fractures restricted to their apophyses.

Professor Paul F. Eve[4] reports two cases of gunshot injury of the spinal column, which the victims long survived, and in which the missiles remained lodged in the spine. Again, Surgeon C. S. Tripler, U. S. Army,[5] relates the case of an officer who, in 1839, during the last Seminole campaign in Florida, was wounded in the loins by a rifle-ball, which penetrated on the right side, in a line with the junction of the last dorsal and first lumbar vertebræ, struck the spinal column, lodged, and was not extracted. There were complete paraplegia and priapism, with retention of urine and feces. He survived for twelve years. The paralysis, however, but slightly improved. The catheter, and laxatives or enemata, had to be used for about two years, that is, until, in 1841, he found that he could stimulate the bladder and rectum to contract by tickling the side of his penis behind the corona glandis.[6] M. Hutin, of the French Army,[7] mentions the case of a soldier, aged 20, who, in 1835, was wounded in the loins, in Algeria. The ball entered on the right side, near the first and second lumbar vertebræ, and, lodging therein, was not extracted. There was immediate paraplegia. In three months the wound healed. This soldier survived the injury fourteen years, and died of Bright's disease. An *autopsy* revealed the ball lodged in the spinal canal; it had severed the right half of the cauda equina and displaced the left half; medullary substance much disorganized. M. Louis, the most celebrated French surgeon of the eighteenth century,[1] relates the case of a soldier who, in 1762, received a gunshot wound of the dorsal spine, in consequence of which he became completely paralyzed in the lower limbs; the wound was enlarged at once, and the ball taken out. Louis saw the patient on the fifth day after the casualty; he found that there were several fragments of bone pressing upon the spinal cord. He removed these fragments; and, although there was a considerable suppuration after this operation, the paraplegia slowly but gradually disappeared, and the patient was completely cured, excepting a slight weakness which remained in his lower limbs. Twelve years afterward, however, he still had to walk with a cane. These facts and examples are mentioned mainly with a view to encourage surgeons to conduct in a thorough manner the treatment of gunshot fractures of the spinal column, in all instances which come under their care, by showing that, even in cases where recovery is impossible, life may be greatly prolonged by careful treatment.

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[1] Am. Journ. of the Med. Sciences, October, 1864, p. 315.

[2] Op. cit., pp. 116, 117.

[3] Medical and Surgical History of the War of the Rebellion, First Surgical Volume, p. 453.

[4] American Journal of the Medical Sciences, July, 1868, pp. 103–107.

[5] New York Journal of Medicine, 1851.

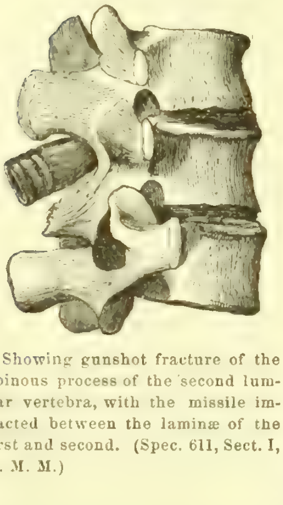
[6] A case of shot fracture of the seventh dorsal vertebra, with paraplegia, is mentioned on p. 438, of the First Surgical Volume of the Med. and Surg. History of the War of the Rebellion, in which tickling of the glans penis likewise produced urination, and partial evacuation of the bladder, by exciting the detrusor urinæ muscle to contract. (See page 813, *infra.*)

[7] Lancet, 1849.

The prognosis of these cases is rendered much more unfavorable by the occurrence of inflammation of the spinal membranes or spinal cord, as doubtless happened in the following instance:—

A soldier, aged 19, was admitted to Emory Hospital, Washington, August 25, 1862, for a gunshot wound of the back, received on the night of the 22d. He was then in great pain and very restless, but not paralyzed in any part. An anodyne was prescribed, with cold applications to the wound. He passed a restless night, and morning found him wearied and anxious, very restless, with an occasional tetanic spasm, though not severe. An anæsthetic was administered, the wound was enlarged, and the missile (a conoidal musket-ball) was found impacted between the laminæ of the first and second lumbar vertebræ, the spinous process of the second having been broken off, as shown in the accompanying wood-cut (Fig. 789) which represents the specimen. The missile was extracted with much difficulty. All spiculæ of bone were then carefully removed, the wound was drawn together by adhesive straps, and cold-water dressings were applied. The operation of an enema of assafœtida and turpentine left the patient in a profound sleep, disturbed occasionally, however, by slight spasms of short duration. His bowels acted twice that night; the micturition was free, and there were no symptoms of paralysis. On the 27th, there was marked increase in the severity of the tetanic symptoms. The enema was repeated, but without effect. Chloroform was now brought to his relief, and its use continued until 10 A. M., when he died. *Necroscopy.*—The ball was found to have destroyed the spinous process of the second lumbar vertebra, and to have buried itself, apex foremost, between the laminæ of the first and second, in the spinal canal, bruising and pressing upon the spinal cord.[2]

Fig. 789.



Showing gunshot fracture of the spinous process of the second lumbar vertebra, with the missile impacted between the laminæ of the first and second. (Spec. 611, Sect. I, A. M. M.)

The condition of the spinal membranes does not appear to have been noted at the autopsy. Nevertheless, the symptoms which characterized this case, *e. g.*, the intense rachialgia, the extreme degree of restlessness, and the tetanic spasms, are symptoms which often present themselves in cases of idiopathic, as well as in cases of epidemic, spinal meningitis; and, no doubt, there was traumatic spinal meningitis of an acute character in this case. The patient survived the onset of the acute symptoms, less than two days. It also appears that chloroform was administered continuously for several hours before death occurred. Was the proximate cause of death the disease, or the chloroform which was administered in order to relieve the symptoms? In six additional cases of gunshot injury of the vertebral column, during the late civil war, analogous symptoms were reported; and it appears that these cases were all fatal.

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[1] Mémoire posthume. Archives Gén. de Médecine, etc., Août, 1836, p. 397; Brown-Séquard's Lectures on the Central Nervous System, p. 251.

[2] Medical and Surgical History of the War of the Rebellion, First Surgical Volume, p. 444.

Another bad prognostic in gunshot injuries of the spinal column is the occurrence of *bed-sores*, especially when they arise from the trophic disorder of the tissues which results from lesions of the spinal cord.

A still more evil portent in such cases is the appearance of *metastatic abscesses*, especially when they spring from the septicæmia that results from suppurative inflammation of the cancellated tissue (osteo-myelitis) of the fractured vertebræ. A considerable number of instances of this sort were reported during the late civil war; and metastatic abscesses arising from this cause were more recently observed in the case of President Garfield, already mentioned above, where it is stated that the fractured spongy tissue of the injured vertebræ was suppurating, and that the adjoining intervertebral cartilages were partly destroyed by ulceration.

Diagnosis.—The presence of an open wound that has been made by a gunshot missile, the track of which extends in a direct line to the vertebral column, the impairment of function evinced by the stricken portion of the vertebral column, and the exploration of the wound with a finger, whenever practicable, by which the fragments of the broken vertebræ themselves can be felt, usually suffice to establish the diagnosis in a satisfactory manner.[1]

Treatment.—If the missile has lodged, it should be found and extracted, if possible. All foreign bodies, *e. g.*, bits of clothing and of accoutrements, blood-clots, and detached or quite loosened splinters or fragments of bone, should likewise be extracted. The utmost cleanliness should be observed, antiseptic dressings should be applied, drainage-tubes should be used to prevent any collections of matter from being formed in the wounds, and necrosed fragments of bone should be removed as soon as they become detached. Fragments of the vertebræ were extracted, after gunshot fractures thereof, in twenty-four instances during the late civil war. Of these cases only ten were fatal.[2] In all of the fourteen cases which did not prove fatal, there was recovery more or less complete. In seven of the nine instances in which the spinous process alone, or portions of it only, were extracted, the patients recovered speedily as well as completely, and were returned to duty, or exchanged. In one instance belonging to this category, which was under my care for two and a half months at Stanton Hospital, there was paraplegia from concussion of the spinal cord, as well as gunshot fracture of the spinous process of the second lumbar vertebra. Several fragments which became detached were promptly removed, and the paralysis, all things considered, rapidly passed away.[3] This man's recovery was complete, for "his name is not on the pension-list, nor have his heirs made application for pension."[4] But, in five successful cases wherein portions of the laminæ or of the transverse processes were removed, the results were much less satisfactory; nearly all of these patients were still suffering from serious disabilities in 1872.[5]

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[1] There is, however, on record the case of an officer, in which a pistol-ball, after fracturing the right humerus, passed into the chest, and, lodging, was not extracted; fifteen days afterwards, he died of pneumonia and secondary hemorrhage. *Necroscopy* showed the missile firmly imbedded in the body of the fifth dorsal vertebra, nearly the whole of which was shattered. Nevertheless, no spinal symptoms had been developed, and the lesion itself had not been suspected during life. The specimen is preserved in our Army Medical Museum (No. 3515, Sect. I). (Medical and Surgical History of the War of the Rebellion, First Surgical Vol., p. 436.)

[2] Medical and Surgical History of the War of the Rebellion, First Surgical Vol., p. 459.

[3] American Journal of the Medical Sciences, October, 1864, p. 327.

[4] Medical and Surgical History of the War of the Rebellion, First Surgical Vol., p. 459.

[5] Ibid.

Again, in order to prevent the occurrence of inflammatory lesions in the spinal membranes and spinal cord, absolute quietude should be enjoined on the patient. Catheterization, and laxatives, or enemata, as well as the precautions against bed-sores and vesical and renal inflammation which have already been mentioned, should be promptly employed whenever their use is indicated. Whatever complications may arise, *e. g.*, osteo-myelitis of the fractured vertebræ, spinal meningitis, spinal myelitis, septicæmia, bed-sores, nephritis, cystitis, etc., should be promptly met by appropriate treatment.

On Trephining (so called), or Resection of the Spinal Column.

The operation of excising parts of the vertebræ with a trephine, a saw, a bone-forceps, or a chisel and mallet, and removing the same, when they are fractured and displaced so as to cause paralysis by compressing the spinal cord, has been suggested by many surgical writers, the earliest of whom was Paulus Ægineta. It was first performed, however, by Henry Cline, at St. Thomas's Hospital, June 16, 1814, in the case of a man, aged 26, who, by falling from a second-story window, on the previous day, had received an injury of the dorsal vertebræ, with considerable displacement, and had become paraplegic.

The man having been put upon the operating table with his face downward, an incision was made through the skin over the projecting spinous processes, of sufficient length to expose them completely. The muscles were then divided on each side, and, being drawn outward, two spinous processes, which were broken at their roots, were removed. It was attempted (but ineffectually) to remove the eleventh vertebral arch by sawing it through with Machell's circular saw; a chisel and mallet were then employed, and also a trephine, by means of which the separation was effected, and the arch lifted out with an elevator. The operation was considerably embarrassed by the unfitness of the instruments, and occupied considerable time, but afforded no relief. In the evening he complained of pain in the wound; pulse 114. June 17, 2 P. M. Had not slept since the operation; pulse 130. At 6 P. M. he had a fit, and was thought to be dying. June 18, 1 P. M. Had another fit; had great difficulty of breathing, with much restlessness; pulse 140; upper part of body in a cold sweat, lower part warm, but not perspiring. At 4 P. M. the spasms had abated. June 19. He was more tranquil, but gradually sank, and died at 5 P. M. without convulsions, and sensible to the last. *Autopsy.*—The fore and upper part of the body of the twelfth dorsal vertebra was fractured obliquely from above and behind, downward and forward. The upper fragment remained attached by the intervertebral substance to the body of the eleventh dorsal, which had moved forward and a little downward, tearing off the posterior half of the intervertebral cartilage from the top of the twelfth dorsal vertebra. The theca vertebralis was lacerated, opposite the seat of injury, in four places, two of which would admit the little finger. The spinal cord was three-fourths torn through, and the remaining portion was bruised.[1]

Mr. Cline himself candidly stated that he thought the operation had hastened the death of his patient. The lesions for which he operated consisted of fracture of the body of the twelfth dorsal vertebra with displacement (partial dislocation) of the body of the eleventh (to which the fragment of the twelfth still adhered), forward and slightly downward, and extensive laceration of the spinal cord. He removed two spinous processes, and the laminæ of the twelfth dorsal vertebra. The foregoing abstract shows the true character of this operation, the difficulties which attend its performance, and its positive harmfulness as well as its inutility, more clearly and in fewer words, than any disquisition on the subject could do. Moreover, this operation has been repeated many times, without success. Professor Ashhurst has collected and tabulated 41 cases in which it has been performed. Of the whole number of patients, 30 died, 3 were relieved, and 3 received no benefit, while of 5 cases the result is unknown. There is no example of a cure achieved by it on record. Surely the general results in these cases would have been much better if the operation had not been performed. It is not improbable that even the few who were apparently relieved by it would have done better without it. The operation of resection or trephining the vertebræ is unjustifiable, because it does not offer a reasonable prospect of improving the patient's condition in any case, while, on the other hand, there is always reason to fear that it may increase the chances of a fatal termination.

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[1] South's Notes to Chelius's Surgery, vol. i. pp. 590, 591, Am. ed.

M. Louis's operation, which was performed in 1762, is sometimes referred to as the first instance in which the spinal column was resected, but it was not a resection at all. It consisted merely in extracting some loose fragments of bone, on the fifth day, in a case of gunshot fracture involving a dorsal vertebra. The patient improved, but, twelve years later, still had to walk with a cane, as has already been stated above. Moreover, the same operation was performed in twenty-four instances during our civil war, and with quite satisfactory results. But resection of the vertebræ is not admissible in gunshot injuries of the spine. Mr. Guthrie[1] mentions a patient who had received a pistol-shot which lodged in the last dorsal or upper lumbar vertebra, and caused complete paralysis of both limbs, and who searched London and Paris, in vain, to find a surgeon willing to operate on him. Professor Paul F. Eve, of Nashville, Tenn., however, once did attempt to perform such an operation,[2] in the case of a Confederate soldier, who had been wounded by a pistol-ball that entered to the left of the spinal column, about one inch from the spinous process of the sixth dorsal vertebra, in the cavity of which, or of the seventh, it was supposed to be lodged. Paraplegia immediately ensued, and the paralysis proved to be permanent. Concerning the operation of resecting the dorsal vertebræ, which was attempted, Prof. Eve says: "After due preparation, a free incision was made through the cicatrix, and an attempt made to follow this into the vertebral cavity; but so deep was the vertebral groove down to the transverse processes, so indistinct the track of the missile—indeed, we could not trace it—so deceptive the intervertebral foramina, etc., but, above all, so great the risk of exciting inflammation by wounding the sheath of the spinal cord, that we concluded, after using one crown of the trephine, of medium size, over what all believed to be the hole made by the bullet, to desist from further application of it. I am satisfied," he continues, "that this operation, in the dorsal vertebræ, if not almost impracticable, is certainly one of the most difficult in surgery."

That the operation of trephining the spinal column or resecting the vertebræ will not relieve the spinal cord from compression, when it is exerted by the extravasation of blood, is proved by the case of a derrick-man, aged 41, in whom the laminæ of the tenth dorsal vertebra were resected, at Bellevue Hospital, by Dr. Stephen Smith; for, notwithstanding that from 8 to 12 ounces of extravasated blood, having a dark color, escaped from the spinal canal after the depressed bone had been extracted, the compression of the cord from extravasated blood, and the paraplegia, steadily crept upward, and finally caused death by asphyxia.[3]

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[1] Commentaries, etc., p. 541, Am. ed.

[2] American Journal of the Medical Sciences, July, 1868, p. 106.

[3] New York Journal of Medicine, 1859, pp. 87, 88.

III. INJURIES OF THE SPINAL MEMBRANES, SPINAL CORD, AND SPINAL NERVES.

INJURIES OF THE THECA VERTEBRALIS, AND MENINGES OF THE SPINAL CORD.

The spinal dura mater, although but loosely connected with the bodies of the vertebræ, is elsewhere strongly attached to the vertebral walls, at frequent intervals, by means of processes sent out through the intervertebral foramina around the spinal nerves. Consequently, when the vertebræ are fractured, or displaced in luxations, the spinal dura mater is extremely liable to be stretched, bruised, or torn. I assisted, on one occasion, at the autopsy in a case in which there were fissured fractures of the fifth, sixth, and seventh cervical vertebræ; there was little displacement, yet the theca vertebralis was found smeared with blood opposite the fractures, and torn open so widely as to allow the index-finger to pass through with ease. (See page 707.) So too, in Mr. Cline's case, which has just been related, the theca vertebralis, at the autopsy, was found lacerated in four places, two of which would admit the little finger. But to multiply examples of this sort would be useless; for it is quite obvious that, in all fractures of the vertebral rings with displacement, whether the fragments spring back into place again or not, and in all luxations of the vertebræ, the theca vertebralis must be correspondingly injured by the stretching, bruising, or tearing which it of necessity sustains from the sudden displacement, or from the sharp edges and splinters of the broken or dislocated bones.

But aside from strains, bruises, and lacerations, the theca vertebralis may be penetrated by *incised and punctured wounds* of the back. Many instances are on record in which such wounds of the theca vertebralis were made by knives, daggers, swords, lances, arrows, and bayonets, and with such implements of industry as chisels, etc. Several examples have already been mentioned in this article. (See page 676.) When such wounds are attended by a discharge of cerebro-spinal fluid, there is no doubt that the theca vertebralis has been opened. When the wound is situated in the loins, and the discharge of the cerebro-spinal fluid is profuse, the nature of the lesion may be mistaken, and it may be supposed that the ureter has been laid open. There is published in the sixtieth volume of the Medico-Chirurgical Transactions, a case in which a copious flow of limpid fluid occurred from a wound in the back, and in which it was believed that the ureter had been laid open, although it was admitted to be possible that the fluid might be cerebro-spinal. Mr. T. Holmes[1] relates two cases in which a similar copious discharge of watery fluid was caused by a wound of the spinal membranes, which did not involve the spinal cord nor the large nerves, as was proved by the post-mortem examination in one case, and by the position of the puncture in the other. Incised or punctured wounds of the back, which open the theca vertebralis without injuring the spinal cord or spinal nerves, do not, of themselves, produce any nervous phenomena, inasmuch as the loss of the cerebro-spinal fluid is usually but gradual, and the fluid itself is rapidly resecreted. Secondary inflammation of such wounds, however, may interfere with the functions of the spinal cord or spinal nerves, and may even destroy life in that way. But when such wounds are uncomplicated, the prognosis is generally favorable. There may, however, be great difficulty in getting permanent closure of the wound in such cases; but there will be more chance of getting it if treatment to that end be employed at once, than if it be postponed to a later period.

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[1] Lancet, April 29, 1882; American Journal of the Medical Sciences, July, 1882, p. 294.

Gunshot wounds of the spinal dura mater not unfrequently occur. In cases where they are present, the vertebræ are always fractured, and the spinal cord, likewise, is generally injured. Many examples have been presented in the foregoing pages in which the theca vertebralis was torn by gunshot missiles. Sometimes, as in the case of Soteldo (p. 780), the bullet penetrates the theca and lodges therein. In others, it perforates that membrane, and leaves behind an orifice of emergence as well as of entrance. In others still, it tears a furrow transversely across the tube which the theca vertebralis forms when *in situ*, and partially divides the same. The amount of thecal inflammation aroused by gunshot injuries is in most instances, I think, not great. At an autopsy which I made some years ago, in a case in which the last-named form of injury was found, I was rather surprised at the absence of inflammation, although the patient had survived the casualty twelve days, and I made the following note at the time concerning it: "There was moderate inflammatory action, adhesive in character, of the theca vertebralis. It was confined to the immediate neighborhood of the wound. There was no pus." It is my belief that the spinal dura mater is normally endowed with a wonderful ability to resist traumatic lesions and their consequences. But injuries of the spinal arachnoid and pia mater not unfrequently cause inflammations of a destructive character therein, which will be discussed under the head of Traumatic Spinal Meningitis.

Moreover, suppurative inflammation of the connective tissue, and abscess, may occur between the spinal dura mater and the vertebral column, in consequence of the injury thereof, especially when the latter has sustained a simple fracture without displacement; two examples of this have already been presented under the caption of *latent fractures* of the vertebræ. (See p. 755.)

Injuries of the spinal meninges are often attended by extravasation of blood within the theca vertebralis, and compression of the spinal cord resulting therefrom. Many instances have been mentioned in the foregoing pages, and eight additional examples will be presented in the next section of this article.

Treatment.—Incised and punctured wounds of the back, which penetrate the theca vertebralis and let out the cerebro-spinal fluid, should be treated by immediate closure and antiseptic dressings for the wounds themselves, and by absolute quietude for the patients.

Gunshot wounds involving the theca vertebralis require for treatment the removal of all foreign bodies, such as blood-clots and loose fragments of bone, as well as bullets and bits of clothing, the employment of antiseptic dressings, with drainage-tubes, and perfect rest for the injured spine.

Simple fractures or dislocations of the vertebræ, which do injury to the theca vertebralis, should first be "set" or reduced if possible, and then inflammatory action in the injured parts should be restrained by abstracting blood with leeches or cups, by applying cold, and by securing perfect rest for the injured structures.

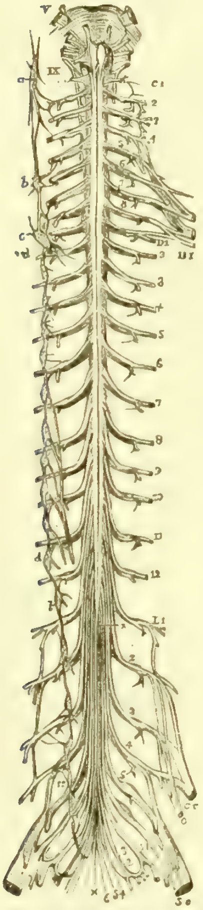
INJURIES OF THE SPINAL CORD AND SPINAL NERVES.

The histological elements of the spinal cord, its nerve-fibres, ganglion-cells, minute bloodvessels, and connective tissue, are so lacking in strength and solidity that, were the cord as a whole not protected from the effects of external violence by an elastic medium, the cerebro-spinal fluid, which everywhere surrounds it, the elementary structures that compose it would be disintegrated by every sudden shock, as well as by every sudden pressure and the impact of every vulnerating body, which might be brought to bear upon it.

The traumatic lesions to which the spinal marrow is exposed are (1) *concussion*, (2) *contusion*, (3) *compression*, and (4) *wounds* (incised, punctured, and lacerated), which partially or completely sever it.

Concussion of the Spinal Cord.—As the symptoms of concussion of the brain result directly from cerebral "shock," so the symptoms of concussion of the spinal marrow result directly from sudden "shock" of that organ; as concussion of the brain is nearly always attended by minute extravasations of blood, or ecchymoses, so probably concussion of the spinal marrow is usually accompanied by minute effusions of blood into its substance;[1] and as the symptoms of concussion of the brain consist of a more or less complete suspension of the cerebral functions, so the symptoms of concussion of the spinal marrow consist of a more or less complete spinal paralysis, which, however, is usually ephemeral in character.

Fig. 790.



Showing the spinal cord and the roots of the 31 pairs of spinal nerves, with the cervical, axillary, lumbar, and sacral plexuses. Also one of the two chains of vertebral ganglia (nervi sympathici), and the communicating threads.

But concussion of the spinal cord, when extremely severe, may instantaneously destroy life. For instance:—

Major Mills, an officer serving on the staff of Major-General Humphreys, then commanding the Second Army Corps, was killed, March 31, 1865, during a reconnoisance, by a cannon-ball (round) which grazed his left lumbar region in such a way as to open the abdominal cavity and let out some intestine. General Humphreys says "he rolled up his eyes and fell from his horse dead." Surgeon Charles Page, U. S. Army (Medical Director, 2d Corps), to whom I am indebted for the case, thinks he must have died from "shock," for there was no solution in the continuity of any organ found on post-mortem inspection which would cause immediate death *per se*. While this view is doubtless correct, it is not improbable that the "shock" itself caused death by producing concussion of the spinal cord of so severe a kind, that all the respiratory muscles, including the diaphragm, were at once completely paralyzed thereby.

Again, death from this cause may ensue in a few hours. For example:—

Morgagni[2] relates the case of a man injured by falling from a vine. He was speechless and paralyzed, and bled from the nose and mouth. The urine and feces escaped involuntarily. Death ensued in four hours. *Necroscopy* revealed fractures of the six upper dorsal vertebræ, ribs, and skull. (Ashhurst.)

Ordinarily, in cases of vertebral fracture or dislocation attended with spinal paralysis, there is at first retention of urine and feces, because the sphincter muscles still remain active, while the muscular coats of the bladder and intestines are paralyzed. Not so in this case, however, for the sphincter muscles, too, were paralyzed from the outset; and this circumstance shows that the nervous centres upon which their activity depends, together with the sympathetic ganglia—the *nervi sympathici*—suffered from concussion as well as the spinal cord.

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[1] There is, however, a case of concussion of the spinal cord on record in which there was paraplegia that persisted (for three weeks) until death was produced by other causes, and, on *autopsy*, no lesion of the cord could be discerned. "No fracture of the vertebræ existed, nor were any appearances found in the spinal column sufficient to account for the persistent paraplegia." Medical and Surgical History of the British Army in the Crimean War, vol. ii. pp. 337, 338.

[2] De Sedibus et Cæsis Morborum, t. iii.

Fractures of the spinal column are often attended by concussion of the spinal cord, much oftener, I fancy, than dislocations are.

Occasionally, concussion of the spinal cord is attended by a peculiarly violent shock to the *nervi sympathici*, as was noted in the following highly instructive example:—

Surgeon A. F. Mechem, U. S. Army, was injured by jumping from a railway train while in motion, June 21, 1870. The fall caused partial concussion of the spinal cord, and severe shock to the sympathetic nervous system. When seen, shortly afterward, slight reaction had come on; still, there was extreme hyperæsthesia of the chest, neck, and upper extremities, which were of a cyanotic hue; cerebral functions undisturbed. The heart's action, almost suspended when first seen, rose under stimulants. When reaction had fairly taken place, there was violent arterial action at the wrist, but unaccompanied by similar action in the temporal and carotid arteries; in fact, the action of these vessels coincided in neither force nor frequency with that of the radial and ulnar arteries. Nor was the action of the heart, at any time after the pulsations became normal, other than healthy, although the extraordinary throbbing at the wrist continued several days. Excepting slight paralysis of the bladder, there was no loss of motor power. At first, the terrible hyperæsthesia of the hands and arms caused a suspicion that there might be a fracture or a dislocation of the cervical vertebræ, which, by pressing upon the spinal nerves, produced the terrible pain. However, a careful examination showed that there was neither fracture nor dislocation, but that the cause of the symptoms was to be found only in the spinal cord and sympathetic nervous system. Morphia was administered hypodermically, and afforded much relief. Cupping, with hot applications of lead-water and laudanum, alternating with fomentations of hops and laudanum, to the arms, hands, and thorax, assisted materially in mitigating the pain. Some three days after the injury, the use of morphia was in a great measure dispensed with, Indian hemp and hyoscyamus being substituted. The hop-fomentations were superseded by applications of chloroform and camphor, alternated with morphia and simple cerate. Tonics, nourishing diet, and stimulants, contributed much toward recovery; but his health remained delicate. In January, 1871, he availed himself of a leave of absence for one month, which was extended six months longer, for the benefit of his health. He died July 14, 1871, in consequence of the accident; no autopsy reported.[1]

Concussions of the spinal cord are often caused by gunshot injuries. I have reported three examples in the American Journal of the Medical Sciences,[2] in an article on Injuries of the Spine. In one of them the spinous process of the second lumbar vertebra was fractured. The symptoms were spinal paralysis (paraplegia), both motor and sensory; the former being more pronounced than the latter, which gradually subsided. Dry cups applied daily over the spinal column were found useful.

The abstract of another case, taken from my field note-book, will considerably aid in illustrating the symptoms of this accident:—

April 6, 1865, I examined a fine cavalry soldier, aged 19, at the field hospital near Jetersville, Va., who had been wounded at Amelia Court House, on the 5th, by a conoidal musket-ball, which passed through the back part of his lumbar region, obliquely from side to side, injuring the spine. He had paralysis, as to motion, of the parts below. The sensibility, too, was diminished, but not entirely destroyed. He complained of hyperæsthesia in the front and inner part of each thigh. He said that he had been hurt in these parts by the fall of his horse, and by being trampled upon, during the cavalry charge at Amelia C. H. on the 5th. He said that both lower extremities felt benumbed. His bladder was paralyzed, and catheterization indispensable. He also said that he did not feel the catheter in the urethra until it reached the prostatic portion. He told this while the instrument was being introduced. Evacuation of the bladder afforded much relief from distress, for which he expressed his gratitude. Was the disorder in this case concussion of the spinal marrow? Yes; for the persistence of sensibility in both lower extremities, when the primary injury was caused by a minié ball, shows that the continuity of the spinal marrow was not seriously impaired. April 8. Saw this patient again at Burk's Junction; condition as to paralysis unchanged. April 11. Still no change; he was sent to-day to the depot field hospital at City Point, and thus passed out of my sight.

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[1] Circular No. 3, S. G. O., August 17, 1871, pp. 112, 113.

[2] No. for October, 1864, pp. 325–328.

Professor Ashhurst[1] relates the case of a soldier, who had sustained a gunshot fracture of the spinous process of a lumbar vertebra, with concussion of the spinal cord. At first, there was spinal paralysis; but the man recovered and was transferred to the Veteran Reserve Corps.

Dr. George McClellan[2] mentions two cases, in which gunshot missiles entered the small of the back and lodged, where their impact caused concussion of the spinal cord and "total paraplegia of all the parts below." The paralysis, however, was but temporary; for both patients got perfectly well again under the use of laxatives and counter-irritants.

The *symptoms* vary greatly with the case, and according to the severity of the concussion itself, from simple motor enfeeblement of the lower extremities, with "numbness" and "pins and needles," on the one hand, to complete paraplegia both motor and sensory, with priapism and retention of urine and feces, on the other. Not unfrequently, intense hyperæsthesia is also present, as was noted in the following very instructive case of concussion of the spinal cord in the cervical region, with ecchymosis of the left posterior horn of gray matter, of the right anterior horn, and of the posterior columns. The injuries resulted from a fall, and the case is related by Sir W. Gull:[3]—

A coal-porter, aged 33, slipped and fell down some cellar-stairs, with a sack of coal falling upon him. He was admitted at 3 P. M., June 22, after the accident; there was loss of motion in both legs and in left arm; the sphincters were paralyzed; sensation was entirely lost in left arm up to deltoid; sensation and motion in right arm perfect; in the lower extremities, he could feel about the feet and on the outer side of thighs, but not on the anterior and inner surface; slight priapism; breathing diaphragmatic. Sensation returned in every part after a few hours; the most distant parts apparently recovered first. As the skin became warm he complained of pain when lightly touched (hyperæsthesia). For instance, when the finger-nail was lightly passed over the skin he exclaimed, "Don't prick me; don't hurt me!" Next day, the cutaneous sensibility appeared to be excessive, judging from his exclamations when the skin was touched or pinched. This was noticed especially in the right arm. The priapism disappeared in two hours after admission, but returned on the day following; power to move the right arm remained; thirty-four hours after the accident the patient died. *Autopsy.*—There was no external trace of injury. The membranes of the cord were healthy. The substance of the cord was contused opposite the fourth and fifth cervical vertebræ. On section, there was found ecchymosis of the posterior horn of gray matter on the left side, and of the adjacent part of the lateral and posterior columns. There were also limited spots of ecchymosis on the right side, one in the right posterior column, and one in the right anterior horn of gray matter. The gray substance generally was hyperæmic. On removing the spinal cord and membranes, nothing abnormal was discovered in the vertebræ until the posterior ligament had been dissected off, when it was seen that the body of the fourth was separated from that of the fifth, and that the left articular process of the fourth had been chipped off.

The essential features of this instructive case are: (1) the cord-substance was injured by concussion, and not by any displacement of the parts; (2) the injury was attended by a number of minute extravasations of blood (ecchymoses) in the gray substance; (3) there were anæsthesia and loss of motion in both lower extremities and in the left arm; (4) there was paralysis of the sphincter ani and sphincter vesicæ, which denoted that the reflex motor apparatus was also paralyzed; (5) the anæsthesia passed away in the course of some hours, the return of sensibility being noted first in the parts most distant from the injury; (6) hyperæsthesia appeared synchronously with the reaction from "shock," and steadily increased in severity; (7) hyperæmia of the gray substance was found as well as ecchymosis. It should be remarked that the hyperæsthesia was more severe in the right arm than elsewhere, and that this part had not at any time been paralyzed.

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[1] Op. cit., pp. 116, 117.

[2] Principles and Practice of Surgery, p. 177.

[3] Guy's Hospital Reports, 1858, pp. 191, 192.

It should also be noted that the hyperæsthesia was coincident in its appearance with the hyperæmia of the cord-substance which followed the injury, and that as the inflammatory excitement caused by the sanguinolent extravasations of blood into the cord-substance, or the hyperæmia, etc., increased or progressed, the hyperæsthesia also rapidly increased until thirty-four hours after the accident, when death occurred.

Treatment.—Inability to urinate and defecate will necessitate the employment of catheterization, and of enemata, or laxatives. When hyperæsthesia is present, it must be subdued by the administration of belladonna, or of opium or morphia. Dry-cupping the dorsal and lumbar regions has, in my own experience, proved very useful in cases of gunshot concussion of the spinal cord. At a later stage, counter-irritation by issues or setons has appeared to do good. But, quietude or rest for the injured spinal column and cord is an important reparative measure, in such instances, fully as important as any other. Not only should the patient be debarred from attempting to overcome his "numbness" and his "pins and needles" by exercise, which caprice or habit might lead him to do, but he must be kept in bed until these symptoms have passed away. Mr. Hilton[1] mentions the case of a gentleman who had sustained a moderate concussion of the spinal marrow from falling upon his back at Epsom, which resulted in irremediable paraplegia, from inattention to this curative measure. Should the symptoms of myelitis supervene, they must be combated by the remedies for that disease which will be mentioned further on.

Contusion of the Spinal Cord.—Bruises of the spinal marrow, like bruises of the cerebrum, are attended by disintegration of the elementary tissues thereof, and minute extravasations of blood, or ecchymoses. There is, however, this important difference between them; for, inasmuch as the cineritious substance is mostly found on the exterior of the cerebrum and within the interior of the spinal marrow, so the ocular evidences of contusion are usually seen, most distinctly, on the exterior or cortex of the former, and within the interior of the latter; and it frequently happens that contusions of the spinal marrow are not discernible by the unaided eye, until the parenchyma thereof is laid open by an incision, and until the cineritious substance is thus exposed to view.

The slighter examples of contusion of the spinal cord, those in which the ecchymoses are not large nor numerous, are commonly, and almost unavoidably, classified, in practice, with the cases of concussion of the spinal marrow which have just been described, and in which the symptoms of spinal concussion constitute the chief clinical phenomena, and among which, at the bedside, no differential diagnosis between concussion and contusion of the spinal marrow can be made. The following case, observed by Mr. Savory,[1] will serve to show what the symptoms are in severe contusions of the cord:—

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[1] Op. cit., p. 33.

A man fell upon his head from a railway van. During the first few minutes he was stunned, but this soon passed off. When admitted to hospital, there was complete loss of motion and sensation in the lower and upper extremities, and in the trunk nearly as high as the clavicles. The respiration was entirely diaphragmatic, the thoracic walls sinking inward at each inspiratory effort. No reflex action could be excited in the lower extremities, nor elsewhere. The pupils were moderately and equally dilated, but sluggish. There was partial priapism. Death ensued in about thirty hours. *Autopsy.*—There was no fracture nor displacement at any part of the skull or spinal column; there was also no hemorrhage nor material congestion at any part on the surface of the brain or spinal cord. But a longitudinal section of the spinal cord revealed, opposite the fourth cervical vertebra, a clot of blood which was extravasated in its substance to the extent of about half an inch. This extravasation was well defined, and nothing wrong could be perceived in the adjoining or in other parts of the cord.

In this case the functions of the spinal cord were completely abolished in two important particulars: 1. There was entire loss of sensation and voluntary motion. 2. There was also total absence of any reflex action. While the clot of blood, the product of contusion, which was found in the substance of the spinal cord at the autopsy, accounts satisfactorily for the former, it does not for the latter; for while the blood-clot might completely destroy the power of the spinal cord as a *conductor* of impressions, it could not destroy its functions as a *reflector* of impressions or as a nervous centre. And inasmuch as the loss of reflex action, observed during life, was due to destruction or impairment of the spinal cord as a nervous centre, it must, as pointed out by Mr. Savory, have arisen from the concussion to which the spinal cord was subjected by the accident, although it produced no effect on the structure of the cord that was visible after death.

This loss of reflex action in the spinal nerves, in consequence of concussion of the spinal cord, mentioned above by Mr. Savory, I had myself previously observed; and I specially noted it at the time of making the observation, although I did not then understand its rationale. The following abstract is taken from the note-book in which the minutes of the case were written at the time:—

Private John H. Rhodes, Company A, 16th Pennsylvania Cavalry, aged 22, was admitted from our front before Petersburg to the Depot Field Hospital, at City Point, December 14, 1864, for injury of the spine and paraplegia. On the 15th, I examined him with much interest. It appeared that he had been hurt, while lying face downward on the ground, on Sunday, the 11th, by the falling of a tree, some branches belonging to the top of which struck him violently across the back and shoulders. He was immediately deprived of the use of his legs and the lower half of his body. When I saw him, all the parts below the umbilicus were completely paralyzed, both as to sensibility and voluntary motility. The bladder required a catheter to be introduced twice a day; the urine was more abundant in quantity than natural. He passed a consistent stool unconsciously in bed on that day. "I failed to excite any sensibility or any reflex action by tickling the soles of his feet, or by pulling the hairs of his legs, thighs, or groins. Both extremities were alike in these respects." Above the umbilicus, sensibility gradually appeared in the skin, at first indistinctly, but increasing with the upward progress of the examination, until it became normal on the upper part of the thorax. The respiration was abdominal (diaphragmatic), and superior thoracic (superior intercostal). He had good use of both upper extremities, and made no complaint of them whatever. He was cautiously turned upon his right side, so as to permit an examination of his back. The consistent stool, above mentioned, was then found in bed. Before this, his bowels had not acted at the hospital. There was no appearance of contusion nor ecchymosis on the integuments of his back and shoulders. There was no deformity nor abnormal mobility found in the spinal column. There was moderate tenderness under pressure when made upon the vertebræ, at the upper part of the dorsal region. He did not complain of being hurt in any part while being turned over in bed. He had considerable cough, with expectoration; sputa unstained. His face had a dusky hue (not deep). He swallowed both solids and fluids without difficulty. Did not complain of distress in any part; no priapism. He died on Saturday the 17th, six days after the accident, from failure of the respiratory function.

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[1] St. Bartholomew's Hospital Reports, vol. v. p. 45.

Autopsy.—Among the muscles, near the upper dorsal vertebræ, a small quantity of blood was found extravasated, but no cutaneous ecchymosis. The laminæ of the first dorsal vertebra and the body of the second were fractured, with but little if any displacement; that is, there was a fissured fracture which extended through the laminæ of the first and the body of the second dorsal vertebra. The anterior common ligament was torn partly through, and the posterior common ligament was loosened or detached to some extent at the seat of fracture. Between the theca vertebralis and the bone, on the left side of the spinal canal, in the same neighborhood, a thin blood-clot was found. It was about two inches long by one-fourth of an inch in breadth, and did not compress the spinal cord. There was no extravasated blood within the theca vertebralis. The spinal cord, externally, presented no abnormal appearance whatever. It was not discolored, nor notched, nor lacerated. But, on making a longitudinal section, the gray substance of the interior was found to present an ecchymosed and contused appearance opposite the fracture, but not elsewhere. Here it was dark-brown in color from the extravasation of blood, and pulpefied in consistence from the force of the contusion. These lesions were symmetrically developed. The spinal membranes and spinal cord were not inflamed. The lungs (both) contained more than the normal quantity of blood, that is, they exhibited passive hyperæmia, but in other respects they were sound.

This abstract touches all the essential points pertaining to concussion and contusion of the spinal cord. The blow struck by the falling tree upon this man's spinal column, as he lay face downward on the ground, suddenly bent it downward (that is, forward) at an acute angle, by severely stretching and so partly rupturing the anterior common ligament, and by making a rent or fissured fracture which extended upward through the body of the second and the laminæ of the first dorsal vertebra. The fragments immediately sprang back into place again. But the blow and the abrupt bending of the spinal column mortally injured the spinal cord. The elementary tissues composing its interior were disintegrated, or reduced to a pulp-like consistence, and were deeply stained with blood extravasated from the ruptured capillaries. The conducting power of the cord was totally destroyed either by the force of the blow itself, or by the pressure which the extravasated blood exerted upon the conducting fibres of the cord. Moreover, the concussion or "shock," which the spinal cord received from the blow, abolished its office as a distinct centre of the nervous system, over a large space, without leaving any alterations of structure whatever to account therefor, that were visible after death. Thus, the man was wholly deprived of reflex motor activity, as well as of sensibility and voluntary motion, in all the parts supplied with spinal nerves which depart from the cord below the lesion of its substance just described. The loss of reflex motor action in the paralyzed parts was as complete in this case, as it was in that which precedes it, and in both alike the post-mortem examination failed to reveal any anatomical cause. From the autopsies of cases such as these, the statement appears to be well founded, that concussion of the spinal marrow, unless it be complicated with contusion, is not attended by any structural change of the marrow which is discernible after death, with the unaided eye.

Anatomical Lesions attending Bruises of the Spinal Cord.—In such cases, the theca vertebralis is very rarely found torn; and, on laying it open, one might imagine the cord to be uninjured, in many instances, because the pia mater of the cord remains entire and without ecchymosis, as it did in the cases just related. On slicing the cord, however, its substance is found to be crushed more or less completely through and through, and blackened by extravasated blood. Sometimes the cord-substance is utterly smashed and broken down into a diffluent pulp throughout a space one inch or more in length, while the pia mater over it remains entire. In other instances, ecchymosis is plainly visible on the outer surface of the cord. Occasionally, this ecchymosis is very considerable in degree and extent.

For instance, Lasalle[1] reports the case of a man, aged 36, and a maniac, who injured his neck by violently throwing his head forward, while struggling against restraint. His head remained bent forward, and there was spinal paralysis. Death ensued thirty-six hours afterward. *Necroscopy* showed that the intervertebral substance between the bodies of the fifth and sixth cervical vertebræ was torn through, without any fracture, and with but slight displacement of the implicated bones. Great ecchymosis, however, was found on the spinal cord.

Symptoms.—Besides the signs of spinal paralysis already mentioned, *e. g.*, the destruction of sensibility, of voluntary motion, and of reflex motor action, in the parts supplied by spinal nerves which issue from the cord below the bruise, another important symptom, namely, hyperæsthesia, is not unfrequently observed.

For example, Mr. Bryant[2] relates the case of a coal-porter, aged 33, who fell down stairs with a sack of coal on top of him, and broke his neck. He had spinal paralysis, priapism, and diaphragmatic breathing; but, after a few hours, hyperæsthesia came on. In thirty-four hours death ensued. *Necroscopy* revealed fracture and displacement of the fourth and fifth cervical vertebræ. The cord was contused but not compressed. The hyperæsthesia does not appear to have been caused by injury of the spinal nerves, but by changes that were taking place in the bruised part of the spinal cord.

There are not yet on record so many examples of contusion of the spinal marrow, with a full account of the symptoms and post-mortem appearances observed in each, that we can safely trust to generalizations drawn from them, and thus dispense with giving the particulars of the cases, when discussing the subject. The details of the following example are very instructive:—

Mr. South[3] relates the case of an old man, aged 68, who was injured and stunned by falling down stairs, and who was admitted to St. Thomas's Hospital a few hours afterward: He had pain at the back of his neck, which was increased by pressure; all his limbs, except the left lower extremity, which still retained slight motion, were palsied; the sensibility of the whole right side of the body was morbidly acute, that of the left totally destroyed, excepting on the belly, where he felt slightly, and to which he referred a sensation of numbness when the left thigh was pinched. Next day he complained of pain in the right arm; the skin on the left side of the belly was less sensible. On the third day the morbid sensibility of the right side had diminished, and sensation had slightly returned on the left. He complained of pain in the right hypochondrium, and fancied that his arms lay across his chest. On the following day the belly became tympanitic. On the fifth day there was slight motion of the left arm, and the capability of moving the right leg had increased; but he was rapidly sinking, although in good heart, and died late at night. On *examination*, it was found that the atlas was broken in two places, the line of fracture being diagonal, and traversing the left vertebral hole. The pivot of the axis was broken off at its root, and a small piece of the body also. The fifth vertebra was fractured through the body. With neither fracture was there sufficient displacement to produce pressure. On cutting through the spinal cord a central cell was found, containing a small quantity of blood, and the substance of the spinal cord was broken down and disorganized opposite the fifth vertebra.

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[1] Gazette Médicale, 1841.

[2] Guy's Hospital Reports, 3d series, vol. v.

[3] Notes to Chelius's System of Surgery, vol. i. p. 585, Am. ed.

This patient survived the accident something less than six days. Both the hyperæsthesia and the spinal paralysis that were observed in his case, arose from the contusion of the spinal marrow, that is, from the disintegration of its elementary tissues, and the extravasation of blood therein, and from the secondary lesions of the marrow, hyperæmia and hyperplasia, which were induced by the injury. Still, as the absorption of the blood extravasated in the bruised part of the spinal cord progressed, the symptoms of spinal paralysis, *e. g.*, the loss of sensibility and voluntary motion, decreased in corresponding degree. The hyperæsthesia also varied from day to day.

To sum up the symptoms which present themselves in cases of contusion combined with concussion of the spinal cord, they are: loss of sensibility, loss of voluntary motion, and loss of reflex motor action in all the parts supplied by those filaments of the spinal cord which are directly or indirectly injured by the contusion of the cord, or which issue from the spinal cord below the seat of contusion, occurring suddenly and coincidentally with the injury of the cord itself; also hyperæsthesia which, not unfrequently, comes on some hours, or even days, after the injury has been inflicted.

Furthermore, concussions and contusions of the spinal cord, like dislocations and fractures of the spinal column, may be attended by very considerable deviations of the body-heat from the normal, both above and below, as was pointed out on page 741. Mr. Erichsen, in particular, has seen spinal concussion attended by marked and prolonged lowering of the vital temperature.

Contusions of the spinal marrow with extravasations of blood into the substance thereof, are of not unfrequent occurrence.

Besides the foregoing examples, M. Brown-Sequard[1] mentions a case by Walker, in which there was dislocation of the fourth cervical vertebra; an incision showed that there was no fracture. The dislocation was reduced, and the patient was improved thereby. Death, however, ensued in six days. *Necroscopy* revealed hemorrhage in the spinal cord.

Mr. Luke[2] relates the case of a laborer, injured by being knocked against the side of a ship, with which the back of his neck came in contact. Projection of the vertebræ in the neck, spinal paralysis, priapism, etc. were noted. In two days death occurred. *Necroscopy* showed fracture of the sixth cervical vertebra; the spinal cord was enlarged and softened; it also contained a blood-clot.

Mr. Solly[3] reports the case of a plasterer, aged 40, who fell from a scaffolding, striking his head, and being stunned. There were paralysis of the right side, a scalp-wound, and a fractured clavicle. He died in forty hours. *Necroscopy* revealed fractures of the fourth and fifth cervical vertebræ; also hemorrhage into the spinal cord, which was soft and bruised.

M. Colin[4] reports a case of hemorrhage into the spinal cord.

Treatment.—The therapeutical indications to be fulfilled in contusions of the spinal marrow are the same as in concussions of the spinal marrow, which have already been described.

COMPRESSION OF THE SPINAL CORD.—The nerve-fibres, ganglion-cells, and bloodvessels of the spinal cord, may be fatally compressed by blood when it is extravasated into the substance of the cord itself, into the spinal meninges (by intra-thecal hemorrhage), or into the spinal canal external to the theca vertebralis; also by the displacements of bone which arise from dislocations and fractures of the vertebræ, and by foreign bodies when they have entered the spinal canal; finally, the spinal marrow may be mortally compressed by the products of inflammatory action which are liable to be effused in all cases of spinal meningitis or myelitis.

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[1] Op. cit.

[2] Lancet, 1850.

[3] Ibid., 1851.

[4] L'Union Médicale, 1862.

Compression of the filaments and other elementary structures of the cord from blood extravasated into its substance, not unfrequently occurs, and examples in considerable number have been presented. But this subject has already been sufficiently discussed in connection with contusion of the cord.

Compression of the spinal marrow from hemorrhage within or upon its membranes has likewise been illustrated in many instances that have been presented in the foregoing pages. As extravasations of blood between the cranium and the cerebral dura mater, or into the cerebral meninges, often destroy life by compressing the brain, so extravasations of blood between the spinal column and the theca vertebralis, or inside of the sheath formed by that membrane, not unfrequently destroy life by compressing the spinal marrow. Mr. Hutchinson,[1] however, asserts that although much has been said about large effusions of blood into the spinal canal as a cause of paralysis, such effusions are, he believes, the rarest of occurrences, for he has "never seen any effusion to the extent of possible compression, and in the majority of cases there is little or none." That this eminent writer's belief on this important point is singularly inaccurate, many cases, already mentioned in this article, in which large effusions of blood were found in the spinal canal, on examination after death, bear strong testimony; and this evidence can be corroborated by presenting many others of a like nature. For instance:—

(1) Dupuytren[2] mentions the case of a soldier having a gunshot wound of the neck. There was almost complete paralysis. Death ensued twenty-four hours after the injury. The *autopsy* showed fractures of the fourth and fifth cervical vertebræ; cord unhurt; much blood effused in the spinal canal, and at the base of the brain.

(2) Murney[3] reports the case of a laborer, aged 22, who fell from a scaffold twenty feet, striking his back. He walked to a neighboring house. In two hours paralysis began; priapism with retention of urine and feces followed; skin hot. Death occurred in four days. The *autopsy* revealed fractures of the fifth, sixth, and seventh cervical, and of the first dorsal vertebræ; no displacement; blood-clots on the spinal cord, which also was softened. (Ashhurst.) In this case, the coming on of paralysis some hours after the accident, and the gradual increment of the symptoms, kept pace with the sanguinolent effusion in the spinal canal.

(3) Hutton[4] records the case of a man, aged 35, thrown from a cart into a ditch. There were "stunning," paralysis, and dyspnœa; and death ensued in four days. The *autopsy* revealed dislocation of the fifth from the sixth cervical vertebra, with slight fracture; cord softened; and extravasated blood. (Ashhurst.) In respect to symptoms and spinal-cord lesions, this case strongly resembles the last.

(4) A very great extravasation of blood occurred within the theca vertebralis in a case under the care of Dr. Stephen Smith, at Bellevue Hospital, some years ago. The patient was a healthy, temperate, and well-nourished derrickman, aged 41, injured by being thrown from a cart and striking his back upon the pavement; he was not rendered unconscious, and did not feel hurt until some one attempted to raise him; then he found that he was paralyzed, and that motion caused him intense pain.

On October 12, P. M., he was admitted to the hospital, two hours after the injury, in a state of collapse; pulse too frequent and feeble to be counted; respiration 18. There were complete sensory and voluntary-motor paralysis of the lower extremities and body up to the sixth intercostal space; moderate priapism; normal temperature. The subjective symptoms were severe pain in the back of the neck, and pain, numbness, and tingling in the arms. Objectively, nothing abnormal was found in the cervical region; but, in the dorsal region, a depression was discovered between two spinous processes in which two fingers could be laid; no corresponding abrasion or ecchymosis visible. A free administration of stimulants, with an anodyne and catherization, were ordered.

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[1] London Hospital Reports, vol. iii. 1866.

[2] Op. cit.

[3] Dublin Medical Journal, vol. xxiv.

[4] Ibid., vol. xvii.

On the 13th, A. M., pulse 112; respiration 26, and mainly abdominal; temperature of trunk and lower extremities exalted. The anæsthesia had progressed upward, having risen to the fifth rib. The pain and numbness of the neck and arms had decidedly increased. The penis was not erect, but it was easily excited on irritating the spine. P. M., sloughs had commenced upon the heel and upon the ball of the great toe of the left foot, and over the external malleolus of the right ankle. A consultation was held, and resection of the depressed dorsal laminæ was agreed upon, and at once performed under chloroform. An incision six inches in length, made in the line of the spinous processes, showed a depression of the arch upon the right side of one of the lower dorsal vertebræ. After some difficulty, the arch was divided on the opposite side, and then the depressed laminæ were pulled out by a duck-billed forceps. Through the opening thus made, from six to twelve ounces of dark-colored, extravasated blood flowed out of the spinal canal. No benefit resulted from the operation, and death occurred soon afterward, apparently from compression of the spinal cord.

The *autopsy* revealed fracture of the body of the tenth dorsal vertebra upon the right side, extending from the base of the transverse process half way to the mesial line anteriorly, without displacement; fracture of the arch of this vertebra upon the right side, with depression; extravasation of blood within the theca vertebralis to a large amount, and extending from the lower cervical vertebræ to the sacrum. From the increasing paralysis it was inferred that this extravasation was still extending upward when the patient died.[1]

This man's accident showed so many things clinically and experimentally, that the history of it is well worth the space consumed. It illustrated compression of the spinal cord, with ascending paralysis from intra-vertebral effusion of blood; it proved that neuropathic sphacelus may simultaneously appear at several different points in the extremities within twenty-four hours after the injury to the spinal cord; it illustrated the inutility of vertebral resection; and it proved that the operation of trephining the spine will not relieve the cord from compression arising from blood effused upon it.

(5) J. Jardine Murray[2] reports the case of a woman, aged 62, thrown from a carriage. There were paralysis and retention of urine, and next day coma; in twenty-four hours death occurred. The *autopsy* showed fractures of the fifth and sixth cervical vertebræ; spinal canal filled with clotted blood; cord unhurt. (Ashhurst.)

(6) Ch. D. Doig[3] relates the case of a porter, aged 37, who fell into the hold of a steamboat, and hurt his neck. There were pain, paralysis, dyspnœa and dysphagia, retention of urine and feces, and insomnia; in four days, death ensued. The *autopsy* revealed fracture and dislocation of the fifth cervical vertebra; clotted blood effused on the spinal cord; cord itself unhurt. (Ashhurst.)

(7) W. T. King[4] reports the case of a laborer, aged 25, thrown from a cart with his neck across a hamper. There were paralysis, etc.; death occurred in fifty hours. The *autopsy* showed dislocation forward of the sixth cervical vertebra; no fracture; and blood extravasated around the spinal cord. (Ashhurst.)

(8) Holt[5] records the case of a man, aged 45, injured by a horse falling upon him. Paralysis came on in the following night; but no cerebral symptoms. In seven days death ensued. The *autopsy* revealed fracture of the fifth, sixth, and seventh cervical vertebræ; blood effused into the spinal canal, and had fallen to the bottom of it; spinal cord uninjured; a tumor in the cerebellum. (Ashhurst.)

(9) Charles Bell[6] mentions the case of a man who fell from a barge into the Thames, at low water. His head stuck in the mud, and he died instantly. Subluxation of the

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[1] New York Journal of Medicine, January, 1859, pp. 87, 88.

[2] Edinburgh Medical Journal, N. S., vol. vii.

[3] Ibid., vol. ix.

[4] Lancet, 1849.

[5] Ibid. 1850.

[6] Observations on Injuries of the Spine and Thigh-bone

seventh cervical upon the first dorsal vertebra was found, and effusion of blood. (Ashhurst.)

(10) Malgaigne[1] refers to the case of a carter, injured by a wheel passing over his neck and shoulder. There were pain, paralysis, etc. In thirty-one hours death occurred. The *autopsy* showed subluxation of the sixth cervical vertebra, with slight fracture. The spinal cord was stretched, and blood effused.

(11) Sir W. Gull relates the following case:[2] A man, aged 40, fell backward from a moderate height with a plank on top of him, and was at once brought to the hospital (4 P. M., July 7). He was collapsed, but sensible, and partially paralyzed in the upper as well as in the lower extremities. No injury of spine discoverable. As reaction came on, and he grew warm again, the paralysis wore off. At 10 P. M. he said he was comfortable. He passed a restless night. At 8 A. M. (July 8) he was entirely paraplegic in the upper as well as in the lower extremities; sensation lost as well as motion; priapism; abdomen tense and tympanitic; the breathing was wholly diaphragmatic; the ribs scarcely moved in inspiration; deglutition difficult; temperature of the surface increased; during the day the skin became intensely hot, but the actual temperature was not noted; fifty-five hours after the accident death ensued. ***Autopsy.*** —No external evidence of spinal injury. "Extravasation of blood outside the theca vertebralis, on its anterior aspect. The effused blood compressed the cord, which otherwise was uninjured. After careful examination there were not found any signs of bruising of its tissue. The extravasation apparently arose from injury to the lower part of the body of the fourth cervical vertebra, which had been fractured, and the intervertebral substance torn. The calibre of the canal was slightly encroached upon by the displacement of the fourth vertebra, but not so as to press on the cord. The extravasation, though not abundant opposite the injury, extended downward to some distance. The membranes of the cord were uninjured." The interspinous and capsular ligaments between the fourth and fifth cervical vertebræ were torn through, and the articular processes dislocated.

It is worthy of remark (1) that the symptoms of paralysis which arose from the "shock" or concussion of the spinal cord, in this case, passed off in a few hours; (2) that there supervened a paralysis, both motor and sensory, which gradually increased until it became complete and extended up to the neck, and which was shown by necroscopy to have resulted from the effusion of blood in the spinal canal between the theca and the bone; and (3) that the substance of the cord did not exhibit any appreciable lesion, notwithstanding the compression it had sustained from the sanguinolent effusion.

Were it essential to a correct exhibit, additional examples might be cited, but these eleven cases, together with some twenty others which have already been related or referred to above, are enough to prove beyond a doubt that compression of the spinal marrow arising from hemorrhage into the spinal canal is not a rare occurrence, as asserted by Mr. Hutchinson; and, furthermore, that any surgeon, however large his practice may be in this class of injuries, is liable to fall into errors of belief concerning them, when he generalizes solely from his own experience.

The *diagnostic symptom* of cord-compression, when it arises from the extravasation of blood in the spinal canal, is paralysis of sensation and voluntary motion, commencing in the legs a few hours after the accident, and gradually extending upward to the chest and neck, as the extravasation progresses upward in the spinal canal, and *pari passu* with the same.

M. Brown-Séquard states, in his Dublin Lectures, that hemorrhage into the substance of the spinal cord may be distinguished from hemorrhage around it, by the sensibility gradually decreasing, and by there being no convulsions. When the hemorrhage is merely around the cord, and compresses the roots of the spinal nerves, there are convulsions, as well as paralysis of voluntary motion.[3]

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[1] Traité des Fractures et des Luxations, t. ii.

[2] Guy's Hospital Reports, 1858, p. 193.

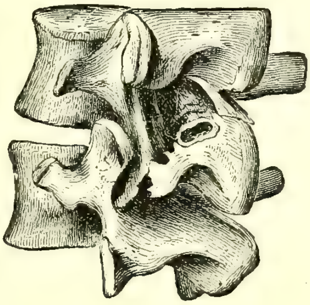
[3] New Sydenham Soc. Year-Book, 1859, p. 41.

Compressions of the spinal marrow, arising from the displacements of dislocated and fractured vertebræ, have already been mentioned with sufficient particularity while presenting illustrative examples of the spinal dislocations and fractures which produce them.

Compression of the spinal cord by foreign bodies which have entered the spinal canal, will be sufficiently illustrated by the subjoined abstract and wood-cut (Fig. 791):—

A soldier, aged 40, wounded May 8, 1864, was admitted to a General Hospital on the 18th, in a paraplegic condition, and died a few hours afterwards. *Necroscopy.*—A conoidal musket-ball entered over the lower ribs on the left side, and, penetrating deeply, had lodged between the laminæ of the second and third lumbar vertebræ and partly in the spinal canal, compressing and bruising the cord. (Fig. 791.) The bladder was distended.[1]

Fig. 791.



Showing the second and third lumbar vertebræ, with a conoidal musket-ball lodged between their laminæ, projecting into the spinal canal, and compressing the cord. (Spec. 3523, A. M. M.)

Compression of the spinal marrow by the products of inflammatory action, as, for example, by serous and by purulent effusion, will presently be discussed under the heads of *Traumatic Spinal Meningitis*, and *Traumatic Myelitis.*

Wounds of the Spinal Cord.—Incised and punctured wounds of the back, which penetrate the spinal column, as well of those made by gunshot missiles, sometimes involve the spinal cord also, and divide it either partly or wholly. Three cases, in which incised or punctured wounds of the back extended into or across the spinal cord, have already been related. (See pp. 675, 676.) In all of them the parts supplied by the cut filaments of the cord were paralyzed. Two recovered (one completely, the other partially) and one died. Inasmuch as the patient who recovered completely, had, for some time after the wound was inflicted, entire loss of voluntary motion and partial loss of sensibility in the right leg and thigh, it was believed that the divided portion of the cord had grown together again, or united, in the course of about two months, when the paralysis ceased *in toto*, and the cure was perfect. In the fatal case there was complete paraplegia, both motor and sensory, from the moment the wound was inflicted. Acute bed-sores (sphacelus) soon supervened, and caused death in thirty-six days after the injury. The cord had been completely divided by the knife, and there was no attempt at reunion.

Dr. Eli Hurd[2] reports a remarkable case of recovery from an incised wound of the spinal cord:—

In jumping from a wagon, the man's feet slipped, and he fell on his back. In attempting to rise he found his lower extremities paralyzed. Calling for help he stated that a chisel, which he had carried in his coat-tail pocket, was sticking in his back; to extract it, required the united efforts of several men. It measured five inches in length to the shoulders, was seven-eighths of an inch in width, and from one-fourth of an inch at the shoulders tapered to one-eighth of an inch in thickness at the cutting end. It had entered to the shoulders. During the extraction, the patient suffered very little, but said that he saw apparently vivid flashes of light, which were followed by total darkness. The wound was opposite the spinous processes of the lower dorsal vertebræ. Total loss of cutaneous sensibility below the wound, with total loss of voluntary motion in the corresponding parts, and paralysis of the bladder and rectum, were the immediate consequences. The patient was prostrated for forty hours, and then reaction was followed by fever for several days. The wound healed rapidly. The urine was withdrawn by a catheter for eight days. Cutaneous sensibility returned on the fifth day, and imperfect use of the limbs about the fifteenth. After five years he still walked with crutches.

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[1] Medical and Surgical History of the War of the Rebellion, First Surgical Volume, p. 447.

[2] New York Journal of Medicine, 1845.

Dr. Hurd fully believed that the spinal marrow was divided in this case, and that afterward it united or grew together again.

Dr. T. Peniston[1] relates another successful case:—

A man, aged 34, received a stab-wound from a dagger between the eleventh and twelfth dorsal vertebræ, on the right side. It was attended by paralysis of the right leg. In eight months he recovered so far that he walked with a cane or crutch. (Ashhurst.)

The following example is very instructive as well as interesting:—

M. Viguès[2] reports the case of a man, aged 28, who was admitted into Professor Nélaton's ward, at the St. Louis Hospital, on February 4, 1850, shortly after he had been wounded in the back with a sword by a police-officer. The point of the weapon, entering three centimetres (one inch) from the line of the spinous processes and to the right thereof, and making a transverse cut one centimetre and a half (half an inch) in length, passed obliquely toward the left and a little upward, between the ninth and tenth dorsal vertebræ, into the spinal canal, and wounded the spinal cord. There were paralysis of the lower extremities, with retention of urine and feces, and marked hyperæsthesia of the left lower limb and genital organs. On February 20, a slough was found on the right side of the sacrum; the patient had not felt anything there. In April, voluntary motion had returned in both limbs, but sensibility was still deficient in the right. On June 15, the patient could walk with the help of a cane; and he left the hospital, although the sensibility was not yet fully restored in his right limb. Three years afterward the patient was again seen; he stated that he was quite well, and that he could walk without difficulty or fatigue; but, a year later, having walked a distance of many leagues, he found a large eschar, produced, he said, by the friction of his pants on his right knee; he had felt no pain, and was surprised when he found this sore. Although the sensibility was still deficient in this limb, its movements were all executed freely and without fatigue.

Without doubt the weapon, in this man's case, gashed the spinal cord extensively, and the severed nerve-filaments reunited in a comparatively brief time. Here is still another successful case of the same sort, which was recorded by Morgagni:—[3]

A young man was struck with a quadrangular and acute poniard, which entered his neck below the left ear, and passed into his spinal cord. Immediately, sensibility and voluntary motion were lost in all the parts below the head. The respiration was enentirely diaphragmatic. He complained of being cold; and, without his feeling it, the application of a hot metallic vase caused burns on his thighs, legs, and feet. On the seventeenth day, he began to recover some feeling in the left side of his body; and, on the twentieth, he began to move the toes and fingers of the same side; these faculties gradually increased. On the thirty-second day, there was a return of some feeling in the right side of his body; movement also, but at a later period, returned slowly there. On the fortieth day, there was sensibility and movement everywhere, but not enough to allow the patient to stand up. The recovery was so slow that, four months after the casualty, he was just beginning to get out of bed, and to walk as a child learning to walk; and, even then, there was less capacity for feeling and movement in the right than in the left side of his body.

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[1] New Orleans Med. and Surg. Journal, 1851.

[2] Moniteur des Hôpitaux, 3 Septembre, 1855, p. 838; Brown-Séquard, op. cit., pp. 97–100.

[3] De Sedibus et Causis Morborum; quoted by Brown-Séquard, op. cit., pp. 103, 104.

It should be observed that the complete loss of sensibility and voluntary motion, which occurred at the outset of this case, arose from the intra-thecal extravasation of blood and consequent compression of the spinal cord, as well as from the section of certain parts of the cord itself by the poniard. No doubt, the severed nerve-fibres reunited in this case also; and the clinical history clearly shows how very slow the process of reunion sometimes is.

But incised and punctured wounds of the spinal cord may give rise to inflammation of the cord and its membranes, and so cause death, as happened in the following instance:—

M. Gama[1] relates the case of a soldier who received a bayonet wound between the twelfth dorsal and first lumbar vertebræ, which injured the spinal cord. On the seventh day he died, without having had any paralysis. There was at the outset pain, which diminished after several venesections. On the second day, however, he had the most excruciating pains and violent cramps in all the parts below the wound, and they continued until his death. There was also extreme hyperæsthesia, and the skin on the lower part of his trunk and inferior extremities was so sensitive that one did not dare to touch him, and he had to keep himself on his knees and hands. *Necroscopy* revealed a wound of the spinal cord. There was an inflammation of the spinal cord and its membranes, and also of the brain.

The pains and cramps in the legs, etc., arose from the meningeal inflammation involving the contiguous spinal nerves. The hyperæsthesia, however, arose in part from this cause, and in part from the inflammatory lesion of the spinal cord, but mostly from the latter. Brown-Séquard has ascertained by experiments upon animals, that a wound on the posterior surface of the cord is followed by a greater hyperæsthesia, in the lower limbs, when made at the middle of the enlargement whence the spinal nerves proceed to these limbs, than when it is made higher.

In *unilateral injuries* of the spinal cord, there is often observed a loss of voluntary motion on the same side of the body, with a loss of sensibility on the opposite side. This point is an important one, and can best be illustrated by presenting the abstracts of a few cases:—

Dr. F. Riegel[2] records the case of a man, aged 22, who was stabbed in the neck with a knife. After being insensible for some time, he presented the following symptoms: On the left side of the body, there were paralysis of all the muscles excepting those of the head and neck, augmented sensibility to touch, changes of temperature, and pain, and increase of reflex irritability; at a later period, there was atrophy of the paralyzed muscles, with corresponding thermometric changes. On the right side of the body there was almost entire anæsthesia as regards all forms of sensation, with complete power of motion. From the symptoms, Riegel concludes that the left half of the spinal cord was divided in the neck. The tremors and reflex irritability were successfully treated with hypodermic injections of arsenious acid. M. Bernhardt gives a case of the same kind.[3]

Boyer[4] mentions the case of a drummer who was wounded in the back of the neck by a sword thrown at him, which penetrated the upper part of the right lateral half of the neck. An incomplete motor paralysis ensued in the right side of the body; and, it was accidentally discovered some time afterward, that sensibility was lost in many parts of the left side. After twenty days, the wound was cured and the man left the hospital, but he was still paralyzed.

Dr. J. Hughlings Jackson[5] reports a stab-wound of the cervical region involving one side of the spinal cord. There were loss of motion and ptosis on the same side as the lesion, and loss of sensation on the opposite side.

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[1] Traité des Plaies de la Tête et de l'Encéphalite, 1830, p. 318; Brown-Séquard, op. cit., pp. 60, 61.

[2] Berlin klin. Woch., 1873.

[3] New Sydenham Soc. Biennial Retrospect, 1873–74, p. 123.

[4] Traité des Maladies Chirurgicales, t. vii. p. 9; Brown-Séquard, op. cit., p. 101.

[5] London Hospital Reports, vol. i. p. 337.

Treatment.—Incised and punctured wounds of the spinal marrow should be treated by closing them immediately with antiseptic precautions, and with antiseptic dressings applied on the outside, in order to get union of the external wound by "the first intention," and thus stop the outflow of cerebro-spinal fluid as soon as possible. To promote the same end, the injured parts should be kept in a state of rest, as nearly perfect as possible. By employing these means, too, the occurrence of spinal meningitis or myelitis may be obviated. It will be remembered that, in a case, mentioned above, of bayonet-wound of the spinal cord, traumatic meningitis supervened, and destroyed the patient. All pains that arise in such cases should be subdued by administering opium or morphia.

Gunshot wounds of the spinal cord are of frequent occurrence. In nearly all the examples of gunshot fracture of the spinal column, which have been above presented to the reader, traumatic lesions of the spinal cord also existed. In the case of Soteldo (p. 780), the missile slightly lacerated the cord, and deposited in its substance a spiculum of bone. In the soldier's case reported by M. Hutin, where there was survival of the injury for fourteen years, death resulting from Bright's disease, the missile divided the right half of the cauda equina, displaced the left half, and became itself firmly impacted in the spinal canal, where it remained innocuous for the time specified. In several instances above mentioned, the missile completely divided the spinal marrow.

To illustrate the phenomena which result from gunshot wounds of the spinal cord, it is advisable to narrate the history of a case that came under my own observation:—

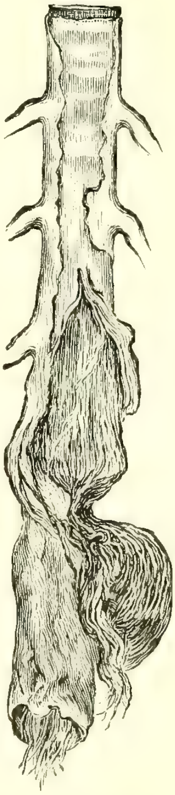
Sergeant A. S. Girt, Co. E, 4th Pennsylvania Cavalry, aged 23, was wounded December 1st, 1864, by a pistol-shot which entered the root of his neck about an inch above the inner end of the left clavicle, passed backward, downward, and inward to the spinal column, perforated the body of the first dorsal vertebra, wounded the theca vertebralis and the spinal cord, fractured the laminæ of the second dorsal vertebra, and lodged on the right side of its spinous process. He was standing at the time, but instantly fell to the ground in a helpless condition from paraplegia. The wound bled considerably at first, but the bleeding soon ceased spontaneously. On the 2d, I saw him at the field-hospital of the Cavalry Division in front of Petersburg, Va. The orifice of the wound was remarkably small, and the integuments surrounding it were considerably swelled and tender, that is, inflamed. There was complete paralysis, both sensory and motor, of the lower extremities, and of the abdomen as high as the umbilicus. He had no power of voluntary motion whatever in those parts. Likewise, I failed to excite any reflex movement whatever by tickling the soles of his feet, and did not produce any sensation by violently pulling the hairs on his legs, thighs, etc. The urinary bladder also was paralyzed, and catheterization was necessary. He had priapism. There was faint cutaneous sensibility just above the umbilicus; and, proceeding upward, this gradually increased until on the thorax it appeared to be normal. His respiration was superior-thoracic and diaphragmatic, or abdominal, but principally the latter. The sensibility of the upper extremities did not appear to be impaired, but the muscular power was considerably diminished, as I readily ascertained by grasping his hands and allowing him to pull. The left arm was weaker than the right. His intellect was undisturbed, and he did not complain of any pain, excepting when the wound and its vicinage were manipulated. On the 5th, I again saw him. He was smoking his pipe as he lay in bed; countenance cheerful, and free from any sign of distress; he said his appetite was good, and that he swallowed without difficulty. The wound was scabbed over, and the parts were less swelled and inflamed. His bowels acted spontaneously in the bed, and he had no control over them whatever, for the sphincter ani had ceased to act. The priapism had disappeared, but the condition of the bladder and other parts, as to paralysis, was unchanged. The respiratory function was quite successfully performed. On the 10th, he was transferred to the Depot Field Hospital at City Point. On the 11th, a dusky hue of the countenance was observed, as if the blood were imperfectly aerated. On the 12th, the breathing became labored and attended with moist râles. The dyspnœa increased; and, on the 13th, he died. An *autopsy* was made by myself on the 15th. The missile had penetrated the root of the neck as stated above, gone through the sterno-mastoid muscle, and, avoiding the great vessels, struck the body of the first dorsal vertebra well in front and slightly to the left of the middle line, bored a hole through the body of this vertebra backward, downward, and toward the right, penetrated the spinal canal, lacerated the theca vertebralis on its front and right sides extensively, cut the spinal cord partly in two, fractured by its impact the right lamina of the second dorsal vertebra, with comminution (it had also fractured indirectly the left lamina), and lodged on the right side of the spinous process of the same vertebra, having passed through the spinal column from before backward, and somewhat obliquely from left to right and from above downward. The fragments were small and did not press upon the cord. The lungs held somewhat more blood than normal, were also moderately œdematous, and the air-passages contained a quantity of frothy unstained liquid. There was moderate inflammatory action, adhesive in character, in the theca vertebralis. It was confined, however, to the immediate neighborhood of the wound. There was no pus. The undivided portion of the cord was pulpefied (contused), and stained with blood, but it did not appear to the unaided eye to be inflamed.

The autopsy of this patient shows that gunshot wounds of the spinal cord are essentially contused and lacerated in their nature, while his clinical history exhibits the symptoms of concussion, contusion, and laceration of the cord, as might reasonably be expected. The loss of sensibility and voluntary motion below the cord-lesion, indicates that the functions of the cord as a conductor of impressions to and from the sensorium were entirely destroyed by the wound, and the loss of reflex motor action shows that the functions of the cord as a nerve-centre were likewise suppressed by the concussion.

When bronchial effusion with moist râles occurred in this case, the man could not get rid of it by coughing and spitting; and, therefore, his dyspnœa rapidly increased until death from suffocation took place. It is worthy of remark that, when complete paraplegia results from injury of the spinal cord at the root of the neck, the power of inspiration is generally preserved, but the power of expiration, as needed particularly for coughing and shouting, is entirely lost.

The traumatic lesions of the spinal cord that result from simple fractures and dislocations of the vertebræ, consist of contusion, stretching, laceration, and complete division. Many examples have already been presented. In Mr. Cline's famous case of resection or trephining the spinal column, the cord was found to be three-fourths torn through, and the remaining portion was bruised. Occasionally, the cord is found to be lacerated in the manner depicted in the accompanying wood-cut (Fig. 792). It represents the appearance which the spinal cord and membranes presented in the case of a soldier whose spinal column was fractured by the limb of a tree falling across his loins. A wood-cut to illustrate the vertebral lesion (transverse simple fracture of the first lumbar vertebra) was given on p. 757, *supra*, Fig. 775, together with the clinical account of the case. Necroscopy showed that the spinal meninges were torn entirely across, excepting a few

Fig. 792.



Showing laceration of the spinal membranes and cord caused by simple transverse fracture of the first lumbar vertebra. (Spec. 150, Sect. I, A. M. M.).

fibres anteriorly and posteriorly, and were congested above and below the rent. Clots of blood were found diffused near the fracture. The lower portion of the cord, severely lacerated, was drawn up into a bundle at the seat of injury, entirely deprived of the membranes. The tubular nerve filaments were seen to be curiously dissected out by the pus in which the cord was bathed, forming a leash which is well shown by the preceding wood-cut. Briefly stated, the vertebral lesion consisted of a transverse fracture extending through the body and pedicles of the first lumbar vertebra, with its spinous and left transverse processes impinging upon the cord. The latter may have been driven into that position by the force of the original blow, as well as by injuries sustained in transportation.[1] The cause of death apparently was septicæmia arising from gangrenous bed-sores.

Occasionally, too, the cord is completely severed by a vertebral dislocation or fracture. For instance:—

Malgaigne[2] mentions a case by Melchiori, in which a mason fell from a height upon his back. There was complete forward bilateral dislocation of the tenth dorsal vertebra. He survived the injury for one day only. The *autopsy* showed that there was no fracture, but that the spinal cord was divided. (Ashhurst.)

Dr. Parkman[3] presented to the Boston Society for Medical Improvement, a specimen in which the third, fourth, and fifth dorsal vertebræ were fractured; the third and fourth were also displaced or projected in front of the sixth and seventh, and were co-ossified in that position. The cord was completely divided; still the patient survived for two months.

In very rare instances, a splinter from a fractured vertebra severs the spinal marrow, as happened in a case related by Abernethy, already mentioned, and in the following:—

Dr. D. S. Conant[4] reports the case, already mentioned above, of a man, aged 55, who was blown off from rigging by wind, and who struck on his shoulders. There were fractures of the last dorsal and first lumbar vertebræ, paralysis, chill, and delirium. Blisters formed on both thighs, before death, which occurred in six days. The *autopsy* showed that a splinter from the first lumbar vertebra had divided the cord. (Ashhurst.)

It may be of interest to state that, in nearly all the fatal cases of dislocation or fracture of the spinal column collected by Mr. Bryant at Guy's Hospital, the vertebral injury was complicated with some structural lesion of the spinal cord; and that, in at least three-fourths of these fatal cases, the cord was irreparably injured by the mechanical pressure of the displaced bones, or by the effusion of blood into its structure.[5]

It is believed, however, that, under favorable circumstances, the nerve-fibres when divided in lacerations (incomplete) of the spinal cord from simple fractures and dislocations, as well as in incised wounds, may unite again, provided that they are not displaced too much, just as the filaments unite again in the nerves of the face and extremities, when divided by accidental wounds or by surgical operations. To support this view, the condition of the cord which was revealed by post-mortem examination, several months after the original accident, in a case recorded by Dupuytren of vertebral fracture with injury of the cord and paralysis, where recovery had taken place, may here be cited:—

Charles Millié, aged 21, was admitted to the Hôtel-Dieu, in 1825, with paralysis of the extremities and bladder, caused by a fall upon the back of his neck. After two months and a half of entire rest, combined with venesection, cupping, and leeching, he recovered, and left the hospital with only slight weakness in the left leg, and with the head bowed slightly forward.

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[1] Medical and Surgical History of the War of the Rebellion, First Surgical Vol., pp. 426, 450.

[2] Traité des Fractures et des Luxations, t. ii.

[3] American Journal of the Medical Sciences, N. S., vol. xxv. 1853.

[4] American Medical Times, 1861.

[5] Lancet, April 6, 1867.

Subsequently he fell and broke his spine again. Thirty-four days after that he died exhausted from bed-sores and colliquative diarrhœa.

The *autopsy* revealed fractures of the fourth and fifth cervical vertebræ, which had united; the callus had been broken by the second fall. "Opposite the point of compression, the cord exhibited an annular constriction, abrupt and well-marked, and very analogous to that presented by the intestine in some cases of strangulated hernia. When incised longitudinally at this spot, the color and consistence of the cord were found altered to a brownish hue, and to the density and firmness of fibrous tissue; a small circumscribed spot, about a line in extent, was especially characterized in this way. The membranes were also more adherent here than elsewhere." It was inferred that the seat of this peculiar change was that of the original lesion of the cord, and that the morbid appearance constituted a true cicatrix of the spinal marrow.[1] Moreover, this case shows that the process of re-uniting the filaments of the spinal cord, when lacerated by vertebral fractures or dislocations, is not a rapid one, and that certainly several months, and possibly several years, must elapse before it can be accomplished.

M. Brown-Séquard's experiments upon animals prove that in them reunion may take place after a wound of the spinal cord, so that its lost functions may return.[2] Furthermore, this eminent observer has sometimes seen a notable return of lost functions (rachidian) in animals, when their spinal columns had been fractured and their spinal cords crushed.[3] The investigations of MM. Masius and Van Lair,[4] in regard to the regeneration of the spinal marrow, show how great the reparative power of this organ really is. These experimenters divided the spinal marrow in frogs, and at the end of from two to four months obtained undoubted evidence that these frogs had regained sensibility and voluntary motility in their hind legs. In other frogs, histological examination showed a more or less complete regeneration of the spinal marrow.

The fact that cases of long-standing infantile spinal paralysis are cured—cases in which there can be no doubt of the existence of the spinal lesion (atrophy of the anterior cornua)—is of itself sufficient evidence to prove that the reparative power of the spinal cord is very great. (Hammond.) Likewise, it will be remembered that four examples of reunion of the spinal cord in the human subject, when it had been gashed by cutting instruments, were presented on pages 799, 800 (*supra*). There can therefore, be no doubt, that the nerve-filaments of the spinal cord may reunite when they have been severed by simple fractures and dislocations of the spinal column.

The *treatment* which such wounds of the spinal cord require, has already been laid down while discussing the simple fractures and dislocations of the spinal column that cause them. Briefly stated, it consists, (1) in withdrawing the vulnerating body from the cord-wound by reducing the fracture or dislocation; (2) in placing the severed cord-filaments in the condition most favorable for reunion by maintaining perfect rest of body; and (3) in turning aside any phlogosis which would retard or prevent their reunion, by leeching or cupping, cold applications, and counter-irritants, used externally, and by opium or morphia, potassium iodide, and ergot, given internally, according to the indications for their employment.

INJURIES OF THE SPINAL NERVES.[5]—In fractures and dislocations of the vertebræ, whether simple or compound, the roots of the spinal nerves are liable to suffer injury during their passage through the intervertebral foramina. Such lesions were undoubtedly present in many examples of these fractures and dislocations which have been mentioned in the foregoing pages; but there is special ground for believing that such lesions were present in those cases of spinal fracture or dislocation where great pain was experienced by patients in the regions of body supplied by the spinal nerves which leave the spinal column at the seat of the displacement (*e. g.*, in the walls of the abdomen at the pit of the stomach, when the sixth or seventh dorsal vertebra is broken or displaced, etc.); for when the peripheral nerves in general are mechanically irritated in any part of their course, painful sensations or increased sensibility (hyperæsthesia) are usually produced in the parts where they terminate, and, when they are divided, these parts immediately become paralyzed, and their paralysis lasts until the severed nerves have grown together again.

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[1] Op. cit., pp. 358, 359.

[2] Experimental Researches applied to Physiology and Pathology, p. 17. New York, 1853.

[3] Lectures on the Physiology and Pathology of the Central Nervous System delivered before the Royal College of Surgeons of England, p. 250. Appendix. Philadelphia, 1860.

[4] Archives de Physiologie, t. iv. p. 268.

[5] See Figure 790, p. 788.

The traumatic lesions which the spinal nerves most frequently sustain at the intervertebral foramina, are such prickings and scratchings of their component threads as cause pains (often severe), or increased sensibility, in the integuments and muscles of the back, where the posterior branches of the injured nerves are distributed, as well as in the integuments and muscles which are supplied by the anterior branches of the injured nerves. Sometimes cramp and other signs of convulsive action are experienced in the parts supplied by the injured nerves. Occasionally the spinal nerves are severed by the displaced bones in cases of vertebral fracture or luxation, and then the parts supplied by them are at once deprived of all sensation, as well as of all power of both voluntary and reflex motion.

Stromeyer mentions an interesting case in which the phrenic nerve must have been contused by a bullet, for during eight days great dyspnœa was present, and the patient was obliged to remain in a sitting posture; it was at first supposed that the lung had been injured, but there were no physical changes on the corresponding side of the chest.[1]

This matter of severe pain being felt in the peripheral extremities of the spinal nerves, when they are injured by fractures or dislocations of the spinal column, is beautifully illustrated by the case of a colored soldier of our army, who received from the conoidal ball of a Colt's navy revolver, January 28, 1866, fractures of the spinous processes of the sixth and seventh dorsal vertebræ, laying open the spinal canal between these processes, and lacerating the cord; for he had great pain in the epigastric region, as well as complete paralysis below the seventh dorsal vertebra.[2]

TRAUMATIC INFLAMMATION OF THE MEMBRANES AND SUBSTANCE OF THE SPINAL CORD.

There are at least two considerable errors which have been long and widely taught by surgeons in English-speaking countries, as well as in others, namely: (1) that when the vertebræ are displaced in luxations and fractures of the spinal column, no effort should be made to restore them to a normal position, that is, that a dislocated or broken spine should not be "set;" (2) that when the spinal membranes and spinal cord, whether separately or collectively, are injured, they are by no means liable to take on inflammatory action, that is, that traumatic inflammation of the spinal cord-substance, and traumatic inflammation of the spinal meninges, occur so very rarely in cases of vertebral injury, that no special thought nor pains need be taken to avert them while conducting the treatment of such cases. The first-mentioned error has already been sufficiently refuted in the foregoing pages. It is now our duty to inquire into the second. In the first place, it should be said that the last-named mistake can have arisen only from the comparatively great infrequency with which the precise condition of the spinal cord and spinal membranes is exactly ascertained by a thorough examination of these structures, after death, in fatal cases of spinal fracture or dislocation. Indeed, it often is no easy matter to make such an examination, or even to get permission to make it, especially in private practice. But, as the membranes and substance of the brain are liable to become inflamed when they are wounded in any manner, so the membranes and substance of the spinal marrow, when similarly injured, are liable to become inflamed, (1) because the anatomical formation of these structures is identical in both; (2) because they extend continuously from one region to the other, the continuity of each structure being preserved intact throughout; and (3) because those inflammations which are essentially diffusive, spread readily from one region to the other, from the spinal canal to the cranial cavity, and *vice versa.* Cases of traumatic spinal meningitis and traumatic myelitis have been recorded much less frequently than cases of traumatic cerebral meningitis and traumatic cerebritis, it may be because post-mortem examinations have much less frequently been made in traumatic lesions of the spinal column than in traumatic lesions of the head.

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[1] Stromeyer, Gunshot Fractures etc.; translated by S. F. Statham, p. 37. Am. ed.

[2] Circular No. 3, S. G. O., August 17, 1871, p. 38.

The following account of traumatic spinal meningitis and traumatic myelitis is largely drawn up from the examples reported by our military surgeons during and since the late civil war, as well as from other reliable observations. In practice, it has been found that both diseases often occur together; but even then, either the one or the other usually predominates, and, therefore, the phenomena presented by individual cases will vary not only in accordance with the severity of the attack, but also in accordance with the disease which predominates, or the anatomical seat of the inflammatory lesion.

Traumatic Spinal Meningitis.—A considerable number of cases in which this lesion caused death have already been mentioned in the foregoing pages.

Symptoms.—This disorder, when acute, is often, but not always, ushered in by rigors or chilliness; pyrexia generally ensues, and the pulse rises as well as the body heat. There are pain more or less severe in the affected part of the spinal column (rachialgia), which is increased by motion; tenderness of the same part under pressure, with increase of temperature above that of the unaffected parts of the organism; and restlessness, sometimes great, with general cutaneous hyperæsthesia, the patient feeling "sore all over." Not unfrequently, pain with cutaneous hyperæsthesia exists in one or more of the extremities; occasionally, when paraplegia is present, the hyperæsthesia of the integuments occupies a band-like space, extending around the body just above the line of paralysis; in some rare instances, where the sensory filaments of the spinal nerves are greatly irritated by the inflammatory process in the adjacent membranes, the hyperæsthesia becomes very severe, and so distressing that words cannot describe the suffering; at the same time, the effects of this inflammatory irritation upon the motor filaments of the spinal nerves are manifested by stiffness and contraction of the posterior cervical and dorsal muscles, whereby the patient's head becomes drawn backward or recurved, so as to deeply indent the pillow; the patient may feel "stiff," as well as "sore all over." When the motor filaments are greatly irritated in this manner, all the muscles supplied by these filaments are affected with tonic or tetanic spasms, and the case may be mistaken for one of tetanus; when the disease spreads to the cranial membranes, there is marked headache with other signs of cranial meningitis; as the case progresses from bad to worse, delirium followed by coma supervenes, and usually death soon ensues; but, occasionally, the tetanic spasms are so severe and extensive as to entirely stop the respiratory movements, thus causing death by sudden asphyxia, and then the mind may remain clear until the last moment. The examples of this disorder are, by their symptoms, clinically separable into three distinct groups: (1) the *foudroyant*, embracing those in which life is destroyed a few hours after the attack, as it were by a thunder-stroke; (2) the *tetanic*, embracing those in which tonic spasms of the muscles constitute the most striking part of the phenomena; and (3) the group embracing those in which *hyperæsthesia* is the predominating symptom.

It should be remarked, however, that the sign which is most characteristic of this disorder, is recurvation of the head and neck from tonic contraction (spasm) of the posterior cervical muscles.

The phenomena of each of the three clinical groups just mentioned will be exemplified by presenting, as briefly as may be consistent with clearness, some abstracts of appropriate cases.

The following abstract of a *foudroyant* case of traumatic spinal meningitis and myelitis is very instructive, as well as interesting:—

A cavalry soldier was wounded, October 14, 1868, in an affray, by a pistol-ball, which entered the right side of his neck, half an inch above, and somewhat external to the greater cornu of the hyoid bone, lodged, and was not extracted. On the 18th he entered the post hospital at Atlanta, Ga. There were complete motor and sensory paralysis of the lower extremities and the right arm, and partial paralysis of the left arm, with spasmodic movement when used; intercostal muscles paralyzed; respiration abdominal, and slow; pulse slow and regular; bowels partially, and bladder completely paralyzed; sensation lost throughout the abdominal region, but normal on the upper part of the chest and the face; intellect clear; patient complained of coldness of the surface, although the skin and extremities were hot to the touch. The track of the ball could not be ascertained, as the wound had nearly healed; but injury of the spinal cord was surmised.

During the *first* week in hospital, mucus constantly accumulated in the air-passages, threatening suffocation, which was averted by the use of stimulating expectorants. The bowels were relieved by injections and purgatives, and the bladder by the catheter. There was no perceptible improvement in the paralysis. A large bed-sore formed over the sacrum.

During the *second* week, there was partial recovery of motion in the right arm, but none of sensation. The patient could, by an effort, draw this arm across his breast. Œdema of the left leg appeared, and was treated by bandaging.

During the *third* week there was no improvement.

During the *fourth* week, on the suggestion of Dr. A. K. Smith, potassium iodide, and afterward tincture of ergot, were given with perceptible benefit. The mucus diminished in quantity, expectoration became easy, and the patient's appetite increased.

During the first part of the *fifth* week, the improvement was very encouraging. The respiration became more normal (that is, ceased to be diaphragmatic), the bowels acted readily, the appetite remained good, and the bed-sores looked healthy.

On November 20, the patient complained of stiff neck, headache [backache], and extreme coldness, and, toward night, had slight fever. On the 21st the fever had subsided, but he still complained of headache [backache] and coldness, and suppuration was diagnosticated. On the morning of the 22d he was comatose, with the left pupil dilated, and the right pupil contracted. A blister was applied to the nape of the neck, purgatives, etc., were given, but to no purpose; he died at 11.15 P. M. *Autopsy*, 15 hours after death.—The missile had passed from the point of entrance mentioned above, toward the spinal column, crossing the carotid sheath externally, and just missing it. It appeared to have penetrated the spinal canal through the third intervertebral foramen, but it could not be found. The membranes of the cord and left hemisphere of the brain were extensively disorganized from inflammation. Plastic lymph, forming a continuous layer, was found effused on the inner surface of the theca vertebralis, throughout the entire length of the spinal cord. The subarachnoid space was distended with a pyoid serum, by which the cord was compressed and softened opposite the third and fourth cervical vertebræ. Here the theca vertebralis was ecchymosed and separated from the bone (by the missile). The layer of plastic exudation extended through the foramen magnum, and along the base of the brain as far forward as the optic commissure. In the anterior lobe of the left cerebral hemisphere, circumscribed softening was found, presenting the appearance of an abscess. The gray substance of this lobe was changed in color and consistence, in consequence of the inflammatory process; the medullary substance was injected; the lateral ventricles were marked by radiating bloodvessels; the corpora striata and optic thalami were injected.[1]

This soldier died very suddenly from traumatic inflammation of the spinal and cranial meninges, the symptoms of which first appeared on November 20, death by coma following on the 22d. The symptoms were rigors, pyrexia, headache, backache, stiffness of the posterior cervical muscles, and coma, death resulting from compression of the brain as well as from compression of the spinal cord, effected by the products of a meningeal inflammation which extended over the whole length of the spinal cord, and over the base of the brain up to the optic commissure. It is probable that hyperæsthesia of the integuments and rachidian tenderness under pressure in the neck were also present at the outset. The anatomical changes wrought by meningeal inflammation are well described. There was a continuous layer of plastic lymph found on the inner surface of the dura mater, extending unbroken from the lower end of the spinal cord up to the optic commissure at the base of the brain. The meshes of the pia mater were also distended by a pyoid serum which lifted up the arachnoid. It is not improbable that this inflammatory attack was directly incited by the autumnal vicissitudes of atmospheric temperature, resulting from what is popularly called "catching cold."

But the history of the first four weeks of this man's case is of equal, if not greater, interest to the thoughtful surgeon. The impact of the missile caused ecchymosis of the theca vertebralis, and separated it from the bone. It also bruised the spinal cord, from which lesion a very extensive paraplegia immediately resulted. Moreover, the bruising of the cord was followed by inflammation of the cord-substance, the symptoms of which were exaggerated reflex motion, particularly noted in the partially paralyzed left arm (for it exhibited spasmodic movements whenever he tried to use it), the sensation of cutaneous coldness without any apparent cause, the formation of a large gangrenous eschar over the sacrum, and the threat of death from suffocation. Next, there occurred a most interesting feature of the case, namely, the great benefit which was derived from potassium iodide and ergot. Under these remedies the myelitis rapidly subsided, the respiration ceased to be diaphragmatic, the appetite and digestion improved, the bowels, etc., acted readily, the bed-sores became clean and appeared healthy, and the case began to look quite encouraging; the existence of the nerve-lesions was proved, after death, by the softened state of the cord-substance which was found opposite the seat of the original injury.

The next abstract presents a brief record of a very instructive case in which *hyperæsthesia* was the most prominent symptom:—

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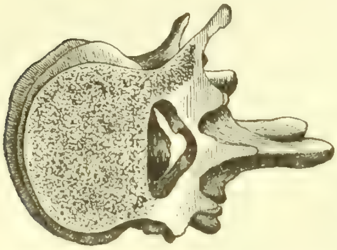
[1] Circular No. 3, S. G. O., August 17, 1871, pp. 23, 24.

A cavalry soldier, aged 28, was accidentally wounded March 26, 1866, by a pistol-shot (conoidal, calibre, 36) which entered his loins near the posterior superior process of the right ilium, some two inches from the spine, passed inward, forward, and upward, struck the spinal column, and finally lodged in the spinal canal opposite the fourth lumbar vertebra (Fig. 793). He instantly fell to the ground; the lower limbs were paralyzed, and over the entire posterior part of the pelvis there was also complete loss of sensation. On the second day, he complained of much pain across the sacral region and in the thighs; could not change the position of the lower part of his body, and all attempts by others to move him gave great pain, especially across the lower part of his back; bowels torpid. He could micturate, but lacked expulsive power to do it readily. Afterward, he slowly improved. About the middle of April he was carried in an army-wagon, sixty miles, to the post-hospital at Austin, Texas, which he entered on April 18. He then looked emaciated and anxious, and was much exhausted by his journey. He complained of pain, especially in the right side of the sacrum, and of severe pain in the posterior muscles of his legs, aggravated by pressure. He could not stand without support, and made no attempt to walk. When lying on his side, he was able to slowly flex and extend his legs, but could not separate them; bowels extremely torpid; urination frequent and very difficult; considerable thirst; but little appetite; upper extremities not affected. Under dry cupping of the sacral region, enemata and laxatives, tonics, nutrients, and alcoholic stimulants, he improved somewhat, but made no attempt to walk. Under the use of strychnia, early in May, his bowels moved spontaneously, and the ability to move his legs was somewhat increased. This medicine, however, was soon discontinued, because it readily exhibited an unduly stimulating action, characterized by the production of diminished sensibility from the haunches downward, with severe pain in the posterior muscles of the legs; appetite decreasing, and debility gradually increasing. During the second week in May and forepart of the third, the patient's general tone diminished greatly; sensibility became lost almost entirely below the knees, but limited motor power still remained. The power to urinate was nearly lost; urine passed in drops, with continued painful desire to pass more (vesical hyperæsthesia); introducing the catheter gave temporary relief, but he could not retain the instrument longer than a few minutes [in consequence of the urethral hyperæsthesia]. From this symptom, belladonna (gr. $\frac{1}{4}$) would, for a considerable period, give most decided relief. The patient lay chiefly on his back, with the knees drawn up; stools passed involuntarily. The pain in the legs and in the sacral region was increased; wet cups were applied over the lower part of the spine, daily, for four days, but without any benefit whatever; he was catheterized twice daily, and this was continued until the end. On May 24, he rejected all food. On the 25th, there was active delirium. On the 27th, the delirium still continued; pulse 120; respiration 40, and performed almost entirely by the diaphragm; no sensation in legs, excepting under hard pressure, but he kept them flexed upon the thighs, and the thighs upon the pelvis; complained of intense pain in the back part of the pelvis, abdomen, and thorax, extending along the spine upward, making it difficult to rest his neck upon the pillow; he described the pain as that of lying upon hot embers; he continued to cry out in pain until a few moments before death, which occurred on the following morning (May 28). *Autopsy*, twenty-one hours after death.—The missile had grazed the right transverse process of the fifth lumbar vertebra, imbedding some particles of lead therein; then, glancing upward, had struck the spinous process of the third lumbar vertebra (its lower border), and had been deflected through the laminæ into the spinal canal. Here, it had been deflected downward by the elastic action of the ligamenta subflava to which the upper border of the broken laminæ remained attached, and had lodged (point downward) within the spinal foramen of the fourth lumbar vertebra. The missile rested within the leash of nerves forming the cauda equina, near the left angle of the spinal foramen (canal), its point reaching downward to the lower border of the fourth

Fig. 793.



Showing a pistol-ball lodged in the spinal foramen (canal) of the fourth lumbar vertebra, and causing meningitis. (Spec. 683, Sect. I, A. M. M.)

lumbar vertebra. The spinal membranes surrounding the point of the missile were lacerated, injected, and of light venous color. The nerve-tissue within the spinal membranes was also injured; it was reduced nearly to a pultaceous consistence; white softening. The fourth and part of the third lumbar vertebra, with the missile attached, was contributed to the Army Medical Museum. This specimen is represented by the accompanying wood-cut (Fig. 793).[1]

The intense agony which was engendered by the hyperæsthesia in this case is something too horrible to be contemplated without emotions of pity.

It is worthy of remark that strychnia did harm to this patient, and that its use was suspended for this cause. It is also worthy of remark that the vesical and urethral hyperæsthesia was notably lessened by giving belladonna, and that the application of dry cups was apparently useful on another occasion.

The next example occurred in the Crimean war. Intense *hyperæsthesia* appeared, and *foudroyant* symptoms. Death from coma (that is, from compression of the brain and spinal cord) resulted in five days.

Private S. L., aged 21, was wounded in the trenches, August 23, 1855. A Minié ball passed through his right cheek, fractured the right alveolar processes and ascending ramus of the lower jaw, with comminution, and lodged near the base of the skull. There was not much hemorrhage. The ball could not be discovered, and every attempt to find it caused very acute agony. There was no paralysis. But deglutition was difficult, and every movement of his neck aroused intense pain, so much so as to cause him to scream violently. Delirium, stertor, and coma set in; death ensued on the 28th, five days after the casualty. *Necroscopy* showed both jaws to be fractured, and the lower comminuted. The missile had lodged just below the basilar process, having broken off and almost detached a large piece of the atlas, and thus uncovered the spinal membranes. They did not appear to have been injured primarily; "but they, as well as the membranes of the brain, showed marks of acute inflammation having been set up."[2]

On the same page, Staff-Surgeon T. P. Matthew, the surgical historiographer of the Crimean War, remarks: "Even where the spinal cord, apparently, was not primarily injured, inflammation of it or its membranes was sometimes set up, and quickly proved fatal."

The following example of traumatic spinal meningitis and myelitis was characterized by the occurrence of *tetanic* spasms of the muscles in the extremities:—

On the first of August, says Stromeyer, I extracted a bullet, which had entered on the 6th of July, between the laminæ of the third and fourth lumbar vertebræ, and there had become fixed. At first there were no severe symptoms; suddenly there occurred violent pains, with cramp in the extremities having similarity to tetanus, and accompanied by delirium. The operation was easily performed by the help of an elevator, after dilating the outer wound. On removing the bullet, a finger could be put into the spinal canal. The patient sank rapidly, and the *autopsy* showed inflammation of the spinal cord and its membranes.[3]

Tetanic spasms of the muscles were likewise observed in the next instance, which occurred in our civil war:—

An artillery soldier, aged 28, was wounded at Gettysburg, July 1, 1863, by a conoidal ball, which entered below the spine of the left scapula, struck the spinous process of the eighth dorsal vertebra, fractured it, but without displacement, and lodged in the angle between the spinous and transverse processes. He walked to the field hospital without assistance, and was able to move about and help himself until the 6th, when tonic spasms of the abdominal muscles and diaphragm set in. They steadily increased in severity; anæsthetics were administered, and the urine was drawn off by a catheter. On the evening of the 7th, he fell into a sleep; but, upon awakening, the spasms returned and continued until 11 P. M., when death occurred.[1] Though the track of the missile was traced in this case, and its place of lodgment discovered by a post-mortem examination, it does not appear that the spinal canal was laid open, and that the spinal meninges and cord were submitted to inspection. Had such an examination been made, the evidences of traumatic spinal meningitis would doubtless have been revealed; for it should be observed that the tetanic spasm first appeared in the muscles (of the abdomen) that were supplied by spinal nerves (the seventh and eighth dorsal) which issued from the spinal column at the place of injury (the eighth dorsal vertebra), and consequently from the focus of traumatic inflammation, whereas true tetanus usually begins with trismus or lock-jaw. There is, then, little room for doubt that the tetanic spasms of the abdominal muscles, etc., which appeared in this case, were merely symptoms or phenomena that resulted from the inflammatory lesions of the spinal membranes and spinal cord.

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[1] Medical and Surgical History of the War of the Rebellion, First Surgical Volume, p. 448.

[2] Medical and Surgical History of the British Army in the Crimean War, vol. ii. p. 337.

[3] Op. cit., p. 38.

Moreover, *tetanic* spasms characterized an example presented on page 782, together with a wood-cut to illustrate it, that bears a strong resemblance to Stromeyer's case as briefly related above. In both, a small-arm missile struck the spinal column, and became impacted between the laminæ of two lumbar vertebræ. In both instances, severe pain in the spine and *tetanic* spasms in the muscles of the extremities ensued. In both instances the missiles were extracted, and both patients died. The autopsy of Stromeyer's patient revealed traumatic inflammation of the spinal membranes and cord. But the autopsy of the other patient does not appear to have been carried far enough to expose the spinal membranes and spinal cord to view. Nevertheless, the symptoms which characterized this case, *e. g.*, the intense rachidian pain, the extreme degree of restlessness or general hyperæsthesia, and the tetanic spasms, constitute a group of symptoms often seen in cases of epidemic cerebro-spinal meningitis when the spinal symptoms predominate; and, without doubt, these symptoms arose in this instance also from an acute inflammation of the spinal membranes, but having a traumatic, instead of an epidemic origin, just as they did in Stromeyer's case.

Epileptiform convulsions, as well as tetanic spasms, are sometimes observed in cases of traumatic spinal meningitis. Charles Bell[2] reports an example in which a subluxation of the last cervical upon the first dorsal vertebra was followed, on the eighth day, by general convulsive movements, accompanied by signs of inflammation of the spinal membranes. The patient died twelve days afterward of exhaustion, not having been completely paraplegic at any time. The *autopsy* showed a little subarachnoidean effusion of serum in the cranium, and an abundant deposit of pus within the theca vetebralis, lying between it and the spinal cord. This case has already been mentioned (page 738).

Pathological Anatomy of Traumatic Spinal Meningitis.—The spinal membranes, like the cranial, are not much disposed when injured to exhibit inflammatory changes of a destructive character. Still, when their vulneration is attended or followed by influences adverse to healing, they, like the cranial membranes, are liable to take on inflammatory action which may cause death. Having thoroughly discussed the symptoms of traumatic spinal meningitis, it is next in order to consider the structural lesions which it engenders. They consist in the exudation of serum, the formation of plastic lymph and purulent matter, and the perforation, etc., of the membranes themselves by ulceration. The following abstract and wood-cut (Fig. 794) will serve to illustrate at least some of these lesions.

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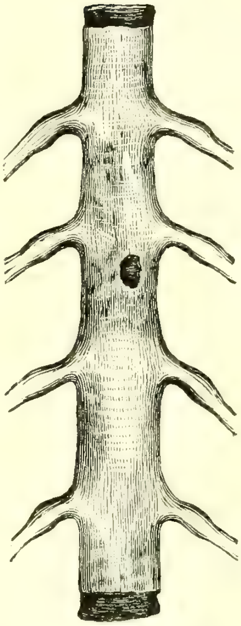
[1] Medical and Surgical History of the War of the Rebellion, First Surgical Vol., p. 452.

[2] Surgical Observations, p. 145.

A soldier, aged 37, received a gunshot wound of the back, at the Wilderness, May 6, 1864; the ball entered over the transverse process of a dorsal vertebra, and lodged in the bone. He was sent to Washington; and, on the next day, he was admitted to Mount Pleasant Hospital. On the 15th, he was transferred to Jarvis Hospital, Baltimore, where he died on July 20, seventy-five days after the casualty, from spinal meningitis. *Necroscopy.*—It was found that the ball had struck the body, and fractured the transverse process, of a dorsal vertebra. The injured bone was necrosed. The spinal membranes showed ulceration and unequivocal marks of intense inflammation, for two inches above and below the fracture. The spinal cord, opposite, was partially disorganized. The inflammatory lesions of the meninges are represented in the adjoining wood-cut (Fig. 794).[1]

Fig. 794.



Showing the effects of traumatic spinal meningitis and myelitis, in the dorsal region. The membranes have been perforated by ulceration, and exhibit other inflammatory changes; cord partially disorganized. (Spec. 3190, Sect. I, A. M. M.)

It does not appear that the spinal cord and membranes, in this man's case, received any direct injury from the blow struck by the missile upon his spinal column. Subsequently, however, the vitality of the bruised vertebra was destroyed by necrosis, and the inflammatory process spread therefrom to the contiguous membranes and cord, when the traumatic spinal meningitis, thus excited, caused his death seventy-five days after infliction of the wound.

The inflammatory process, when it is excited in the spinal membranes by traumatic causes, may be either diffuse or circumscribed in character. In several instances, related above, it was very diffuse, and not only involved the entire extent almost of the spinal membranes, but passed upward through the foramen magnum and attacked those of the cranium. In the last example, however, it was not diffuse, but confined to a space extending two inches above and below the place of injury. In the next case the meningeal inflammation was also circumscribed and restricted to comparatively narrow limits:—

Capt. Thomas H., 67th Regt. Indiana Vols., was wounded by a pistol-ball in the back, November 3, 1863, and entered a general hospital on the 9th. There was partial paralysis of the *left* thigh and extremity. The missile had entered about four inches to the *right* of the fourth dorsal vertebra, but its course could not be traced. The tract of the spinal column, both above and below the wound, was equally sensitive. The paralysis, in the first week, invaded the right leg, the bladder, and the rectum; and, by the end of the third week, sensibility and voluntary motion had disappeared (that is, there was complete paraplegia) in all parts below the wound. The only noticeable instance of excito-motor action which remained was the peculiarity that tickling the glans penis produced a partial evacuation of the bladder; and this feature continued until the patient's death, which resulted from acute pneumonia on December 19. *Necroscopy* showed that the ball had passed downward and inward, slightly wounding the costal pleura; had fractured the right transverse process of the seventh dorsal vertebra; and had lodged in the body thereof, producing a slight exfoliation from the inner side of the body into the spinal canal, which had caused inflammation of the spinal membranes and cord. Pus was found in the theca, that is, in the spinal pia mater. The right lung was far advanced in suppuration.[2]

This case is strictly analogous to those instances of traumatic meningitis and cerebritis which arise from exfoliations from the inner table of the skull, in consequence of cranial injury, and which produce subdural or intra-meningeal abscesses, attended by corresponding palsies of the cerebral functions. In this officer's case, the pressure exerted by the products of the meningeal inflammation (purulent matter and serum) upon the spinal cord, as well as the inflammatory changes which occurred in the cord-substance itself, caused complete paralysis of all the parts of his body which were situated below the spinal lesion.

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[1] Med. and Surg. Hist. of the War of the Rebellion, First Surg. Vol., p. 439.

[2] Ibid., p. 438.

A few words should also be said concerning the *pathological histology* of traumatic spinal meningitis. This disorder usually consists of acute hyperæmia and suppurative inflammation of the pia mater. There is a tolerably well-marked congestion of all the vessels in the pia mater, together with purulent infiltration of the subarachnoid lymphatic spaces. The most striking point in connection with it is the strict way in which the purulent formation is limited to the parenchyma of the pia mater; it never transgresses (when diffuse) the arachnoid lamella which forms its outer boundary. In the first *foudroyant* example related above, the meshes of the pia mater were seen to be distended by purulent serum which lifted up the arachnoid. The comparison of the arachnoid to a serous sac, formerly so popular, has ceased to be entertainable ever since Luschka's investigations proved that the so-called parietal layer of the arachnoid was merely the epithelium of the dura mater. The very striking deviation from the superficial character of serous inflammations in general, just mentioned, completes the demonstration that the arachnoid is not a serous membrane in the same sense as the pleura or the pericardium. "It seems to me," says Rindfleisch, "as though this deviation were simply due to the presence of very distensible spaces immediately around the vessels. Here, if any where, we may apply Cohnheim's theory of inflammatory exudation. Even the naked eye can show us that the pus everywhere originates along the course of the vessels. Like a double-streak of a yellowish-white color, narrow at first and growing steadily wider, the pus follows the edges of the vessels, especially of the large and small venous trunks. The longer the process lasts, the nearer do the purulent streaks accompanying the vessels approach one another, till they finally coalesce; the pia mater swells up as a whole; it often acquires a peculiar stiffness, owing to the stretching of its fibrous bands, perhaps also to the coagulation of some lymphatic constituents of the exudation."[1] It may then be stripped off from the compressed and bloodless, rarely softened, surface of the cord, together with the prolongations which it sends into the sulci, forming a solid mould of the rachidian irregularities. The morbid process generally begins with hyperæmia (active congestion) of all the inter-meningeal vessels at the place of injury, followed by the appearance of serum and flakes of lymph; and it terminates, as just stated, in subarachnoid suppuration.

Treatment.—Traumatic spinal meningitis, whether diffuse or circumscribed, is an exceedingly dangerous disorder; and, to treat it with success, it is indispensable that vigorous measures should be promptly employed. The preventive measures (*prophylaxis*) consist in removing all foreign bodies from gunshot wounds of the spine, and applying antiseptic dressings; in reducing simple as well as compound dislocations and fractures of the vertebræ, thereby lessening the meningeal irritation; in maintaining afterward absolute quietude of all the injured parts; and in promptly abating any inflammation which may arise in the circumjacent structures.

Meningeal congestion should be combated by administering ergot in large doses at short intervals (from 30 to 60 minims of the fluid extract every four hours until the indication is fulfilled), and by giving opium or morphia in such doses and at such intervals as will suppress the rachidian pain.

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[1] Manual of Pathological Histology, vol. ii. p. 309. New Sydenham Society's translation.

The inflammatory process is to be combated by exhibiting one or two purgative doses of calomel at the outset, by abstracting blood locally with leeches or cups, by applying cold to the overheated back, and by administering saline drinks of a cooling, laxative, and diuretic nature. At a later stage, potassium iodide in full doses, and counter-irritation by vesicants or by the actual cautery should be employed. The remedy, however, which is most efficacious to remove meningeal congestion is ergot, provided it be given in sufficiently large doses; while that which is most effectual to prevent the exudation of serum and the formation of plastic lymph (and thus to save the spinal cord from undue pressure), is opium, or morphia, also given in adequate doses.

No attempt should be made to relax the tetanic spasms by administering chloroform or any other anæsthetic; such medication did no good whatever in two cases which are mentioned above, and it probably hastened the end in each. But morphia combined with the bromides of calcium, sodium, potassium, or ammonium, and chloral hydrate, may be used for this purpose.

In treating the paralysis attending the chronic forms of the disease, the bichloride of mercury, in doses of gr. $\frac{1}{16}$ every eight hours, often does good. Strychnia is not admissible, and it clearly did harm in one case above related.

Traumatic Myelitis.—As cerebritis is true inflammation of the *brain-substance*, so myelitis is true inflammation of the *cord-substance*, and as cerebritis presents a marked contrast to cerebral meningitis (or what is popularly known as "inflammation of the brain") in respect to extent, acuity, and phenomena, so true inflammation of the cord-substance differs widely in the same particulars from spinal meningitis (or what is sometimes known as "inflammation of the spinal cord"), which has just been described.

Both cerebritis and myelitis are always *caused* by a wound or an injury in the widest sense of the term—that is, by some local irritation of extra-cerebral or extra-rachidian origin. The skull or the spinal column may have been struck or concussed; it may have been penetrated by a cut, a stab, or a fracture, which has directly damaged the brain-substance or the cord-substance; or a focus of inflammation and suppuration, originating in the neighborhood of the brain or the spinal cord, may have been propagated to its tissues at the point of contact; or, finally, the plugging of a vessel by an embolon, or a thrombus, or the rupture of its coats from atheromatous disease, etc., may have caused a circumscribed, punctiform hemorrhage, followed by inflammation as a secondary consequence.

In myelitis, and in cerebritis, the behavior of the parenchyma proper of the spinal cord and brain is the main point to be attended to; this is usually said to undergo purulent liquefaction; and the statement is so far true that a deposit of pus is usually found to occupy the place of the rachidian or the cerebral substance.

"The phenomena of acute myelitis leading to abscess are exactly similar to those of encephalitis [or cerebritis]. The form of the affected part varies with the [nature of the] injury. Fractures of the spine usually crush the cord; inflammation and suppuration take place around the crushed part, and isolate it from the healthy tissue."[1] Many examples of traumatic myelitis have already been mentioned in this article.

Symptoms.—The acute form of the disease is often ushered in with a distinct chill; pyrexia follows, with thirst and increased frequency of pulse, and the body temperature may rise to 103° Fahr. The affected part is generally the seat of a dull pain or ache (quite distinct, however, from the intense pain of meningitis), which is increased by bending and by percussing the diseased part, and by applying a hot sponge over it. The functions of the spinal cord are immediately disturbed, and notable derangements of the cutaneous sensibility at once ensue. They often take the form of "pins and needles," of a sensation as if water were trickling over the cutaneous surface, as if the limbs were asleep, or as if the cutaneous surface were very cold, while in reality it is very hot, and *vice versa*. It will be remembered that coldness of the surface without any apparent cause was complained of in the first *foudroyant* case of spinal meningitis above related. But anæsthesia is the general condition of the skin that is most common in this disease. It is, however, attended not unfrequently by cutaneous pain or hyperæsthesia; indeed, spontaneous and severe pains are often felt in the skin, when the cutaneous sensibility is already much impaired. Complete analgesia soon follows.

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[1] Rindfleisch, op. cit., vol. ii. pp. 324–330.

The voluntary motility is destroyed at an early period in this disease. At first the reflex excitability may be exaggerated, but it likewise soon disappears. Then the sphincter ani and sphincter vesicæ entirely cease to act, and the feces and urine flow out into the bed without any restraint whatever. The urine becomes alkaline, and oftentimes is thick with mucus.[1] Simultaneously, sacral eschars, or so-called acute bed-sores, are very liable to be formed. These eschars are due less to the patient's position than to the lesion of the spinal cord. In twenty-four hours these bed-sores sometimes appear, and in such cases the febrile movement caused by the myelitis is often mistakenly ascribed to the eschars themselves.

In the *subacute* and *circumscribed* forms of the disease, the aberrations of sensibility are less strongly marked, and they succeed each other less rapidly on account of the slower progress or the more restricted range of the morbid process. The sensation of a band drawn tightly around the body is generally, but not always, present in such cases, and its seat marks the upper limit of the rachidian inflammation. The destruction of voluntary motility and of reflex excitability usually travels upward, *pari passu*, with that of sensibility.

The inflammatory process in traumatic myelitis generally exhibits a remarkable tendency to spread upward in the rachidian substance. This peculiarity was long ago specially noted by Dupuytren, in cases where inflammation of the cord had arisen from dislocation or fracture of the spine. The most frequent mode in which traumatic myelitis destroys life is by paralyzing the respiratory muscles in consequence of its upward spread, and thus causing fatal asphyxia. The following example illustrates this point, as well as several others in the natural history of the disease:—

A cavalry soldier at Fort Gibson, Cherokee Nation, received a shot-wound in the neck, in a brawl, on November 19, 1868, and was taken into hospital shortly afterward. There was complete paralysis of both upper extremities; respiration gasping and frequent; pulse about 100, of fair volume and strength; mind clear; he complained of some pain in the hands. The missile had penetrated the neck, on its left side, at the anterior border of the trapezius muscle, and about two inches below the mastoid process; passed downward and to the right; fractured one or more of the vertebræ; and lodged beyond the reach of the bullet-probe. A few loose fragments of bone were removed. He was placed on a water-bed. Anodynes were given to procure sleep and relieve pain. The bladder was relieved by the catheter. The paralysis of the abdominal muscles allowed gases to collect in the intestines to such an extent as greatly to augment the pre-existing difficulty of breathing. Vent was given to these gases, from time to time, by inserting an elastic tube, *per anum*, and compressing the belly externally. The paralysis from day to day became more profound; the respiration more difficult; asphyxia slowly appeared, with delirium followed by coma, and on the 28th death ensued, about nine days after the casualty. The *autopsy* revealed (1) fracture of the spinous process of the last cervical vertebra; (2) fracture of the laminæ of the first dorsal vertebra at the point where they unite to form the spinous process; this fracture opened the spinal canal and ruptured the theca vertebralis; (3) several small fragments of bone, embedded in the substance of the spinal cord, which was softened and bathed in pus. The bullet had also fractured the first rib with the coracoid process of the scapula, and had lodged in the right axilla, where it was found. The lungs were deeply congested, as was the mucous coat of the bronchi; and the bronchi themselves were filled with a tenacious mucus.[1]

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[1] Dr. C. B. Radcliffe, however, has recorded a case (Lancet, December 3, 1864) in which the urine remained *acid* throughout. The myelitis was acute and very extensive, and in ten or twelve days death ensued. There were retention of urine and marked priapism. The motor and sensory paralysis extended up to a line drawn round the body four inches below the ensiform cartilage; reflex movements absent. *Autopsy.*—Spinal membranes, normal; substance of cord, yellowish-red in color and softened to the consistence of cream, from its brachial enlargement to its inferior extremity; it here consisted of the débris of its normal structure mixed with blood-corpuscles, exudation granules, and some pus-corpuscles.

The injury of the spinal cord in this case was followed by suppurative inflammation of its substance, which not only involved the whole thickness of the cord, but spread upward also. Simultaneously the paralysis became more profound, and rose to higher points, from day to day, until the man breathed by the diaphragm alone. Then the occurrence of tympanites greatly increased the dyspnœa by opposing the descent of the diaphragm; tenacious mucus formed in the air passages, and accumulated therein, because there was no power to expel it by coughing; mucous râles (bronchial) soon supervened, and death from suffocation ensued, ere the disintegrating process had ascended the cord high enough to paralyze the phrenic nerves. This man died of ascending myelitis in nine days. But, on page 749, I have presented the case of another soldier who died of ascending myelitis in about forty-eight hours after sustaining simple fracture of the fourth cervical vertebra, in consequence of falling from a second story. On another page, I have mentioned the case of a man, aged 40, who died of ascending myelitis on the eleventh day after sustaining simple fracture and dislocation of the eleventh dorsal vertebra, with contusion of the cord. I have likewise referred to many other cases of spinal injury, in which ascending myelitis supervened with fatal effect, as was shown by necroscopy.

In the next example, the patient died of hæmoptysis before the inflammatory process in the spinal cord had reached the stage of suppuration:—

A cavalryman, aged 35, entered a general hospital, October 28, 1864, for a wound from a pistol-shot which had penetrated to the left side of the spine, and had fractured the twelfth dorsal vertebra. All below a line drawn from the wound to the pubis was paraplegic. There was much depression; pulse about 130; much pain over abdomen and right side; constipation; incontinence of urine from overflow of bladder. A catheter was introduced and three pints of very thick, dark-colored urine were withdrawn. Stimulants, tonics, and a cathartic were given, with an anodyne at night. The patient improved and did well until November 15, when a bad cough set in. He died suddenly on the 18th from hæmoptysis. *Necroscopy.*—The spinal canal was laid open posteriorly from the second dorsal vertebra to the sacrum. Upon removing the spinal cord, the theca was found congested and firmly adherent to the vertebræ. The substance of the cord looked very red. The ball had passed between the arches of the twelfth dorsal and first lumbar vertebræ, and then through the body of the twelfth dorsal, outside of the spinal meninges; but its track could not be further traced. The right pleural cavity contained three pints of dark, bloody, stinking fluid. The muscular tissue in the lumbar region was very dark and softened, but contained no abscesses nor infiltrated pus.[1] Death occurred three weeks after the infliction of the wound.

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[1] Circular No. 3, S. G. O., August, 17, 1871, pp. 21, 22.

The membranes and substance of the spinal cord, in this case, exhibited the signs of convalescence from inflammation, and that process must have run pretty high at one time, for the theca vertebralis had become strongly adherent to the spinal column. The spinal membranes were still congested, and the cord-substance looked very red, when exposed to view at the autopsy.

Pathological Anatomy.—This reddened hue of the rachidian parenchyma is accounted for by the peculiar manner in which the vascular apparatus is involved. The intense hyperæmia which ushers in the morbid changes invariably gives rise to a large number of minute ecchymoses; these, of course, are equally numerous when the hemorrhage is the primary and the inflammation the secondary phenomenon. Should the affected part undergo softening and purulent liquefaction, the extravasated blood mingles with the pulp, and imparts to it a more or less intensely red color. Hence, the term *red softening* is generally applied to parts affected by encephalitis (cerebritis), or by myelitis; but this term is equally applicable to other cases in which similar effects are produced by very different causes. The presence of pus is characteristic of the inflammatory form of red softening; so, too, is the presence of an areola, from one to two lines in width, in which the parenchyma is studded with numerous bloody points, and swollen by a commencing purulent infiltration. (Rindfleisch.) But purulent softening had not yet appeared in the example just related; or, rather, the hyperæmia of the rachidian parenchyma, which was very intense and accompanied by a great multitude of minute extravasations of blood, seems to have been passing away, that is, undergoing resolution or cure, the intensely red hue arising therefrom alone remaining. I have dwelt somewhat upon this case, because it affords sure ground for the hope of obtaining a cure by timely medication in analogous cases of traumatic inflammation of the membranes and substance of the spinal cord.

But when, on the other hand, resolution of acute hyperæmia of the cord does not occur, either spontaneously or in consequence of treatment, purulent infiltration of the reddened tissue will ensue, and purulent matter will take the place of the rachidian substance. Concerning the manner in which the liquefaction occurs, no unquestionable theory can be advanced in the present anarchical state of our doctrines concerning suppuration. "We can but express suppositions, keeping a firm hold on individual facts of unquestioned certainty to serve as guides. Among these I include," Rindfleisch justly observes, "the passive behavior of the nervous elements in the suppurative process, and the intense activity of the vascular system in every stage of the disease. The nerve-fibres within the affected area are partly suspended in the pus as disconnected fragments, partly protruded from the walls of the cavity in a state of advancing maceration and decay. I have not been able to detect any traces either of fatty or of granular degeneration in them; drops of myelin separate from their surface; the axis-cylinders grow thinner by degrees, and finally disappear. The ganglion-cells of the affected part become darkly granular, and break up into splinters; I have often recognized well-marked fragments of them in the pulp."[2] From what source comes the purulent matter in such cases? The same indefatigable observer remarks:—"My own investigations have taught me that the pus first collects around those vessels from which extravasation [of blood] has occurred. In transverse sections of the encephalitic foci (red softening), hardened in preservative fluids, we find these vessels girdled by a relatively wide areola of pus-cells; and by dint of careful management, we may even pull vessels coated with pus—furnished with regular sheaths of pus-corpuscles—out of the recent specimen. Finally, we may also see in the transverse sections that the pus has actually pushed the extravasated, but still fluid, blood away from the vessels, the blood-corpuscles forming a ring around the pus, instead of a globular drop. This would lead us to infer that the pus was generated by the adventitia, or furnished by the emigration of leucocytes. Nevertheless, I am loth to refuse the power of generating pus to the neuroglia; I am quite sure that it is capable of producing corpuscular elements (solitary tubercles, gliomata); and, although I regard the results of my inquiries, just given, as trustworthy so far as they go, yet I do not consider them exhaustive."[1] The purulent matter, then, in such cases, (1) arises from the emigration of leucocytes; (2) is generated by the adventitia; and (3) is probably produced also by the neuroglia; but, whatever be its origin, it destroys and takes the place of the inflamed substance of the cord. Thus suppurative inflammation of its substance may demolish the structure of the spinal cord, not only through and through, but upward as well as downward for a considerable distance in its continuity. Thus come to pass the disorganized and liquefied conditions of the spinal cord revealed by necroscopy in cases of vertebral fracture or dislocation, where death has occurred some days or weeks after the accident, many examples of which have been mentioned in the foregoing pages.

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[1] Medical and Surgical History of the War of the Rebellion, First Surgical Volume, p. 441.

[2] Op. cit., vol ii. p. 325.

To emphasize this important point, a few brief abstracts will here be added:—

(1) Zambaco[2] mentions the case of a man having fracture and luxation of the third dorsal vertebra. The compression of the spinal cord was not constant; it could be relieved by pressure. However, death ensued eighteen days after the injury, through the lungs; that is, from asphyxia. (Ashhurst.) No doubt, the injury of the cord in this case caused ascending myelitis which disorganized the cord in the upper dorsal and lower cervical regions, paralyzed the respiratory nerves and muscles thereby, and thus completely arrested the respiratory movements.

(2) Luke[3] reports the case of a man who had fracture of the seventh dorsal vertebra. The displacement was corrected by making extension, and reduction was accompanied by an audible sound. Death from erysipelas supervened seven days after the accident. On *autopsy*, the spinal cord was found to be softened and disorganized, and to contain purulent matter. (Ashhurst.)

(3) Dupuytren[4] mentions the case of a man injured by jumping from a third story. There was deformity of the spinal column in the lumbar region, with great mobility; paralysis, at first partial, but afterwards complete; and bed-sores. Death resulted. The *autopsy* revealed fracture of the second dorsal vertebra; the spinal cord was liquefied; and a purulent cyst was found by the tenth dorsal vertebra. (Ashhurst.)

(4) Adams[5] relates the case of a woman, aged 28, who fell ten feet, striking the head. "Grating in the neck" was felt; there was a protuberance in the pharynx and a depression in the back of the neck; paralysis; pain; dyspnœa; retention of urine; insomnia; involuntary evacuation of the bowels; bed-sores; and convulsions. In twelve days death ensued. The *autopsy* revealed dislocation of the fifth from the sixth cervical vertebra; also fracture of the sixth dorsal vertebra. Opposite the latter point the spinal cord was divided, and above it the cord was softened. (Ashhurst.) Here again was shown the remarkable propensity to travel upward, which characterizes traumatic myelitis.

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[1] Ibid., p. 326.

[2] Rec. des Trav. de la Soc. Méd. d'Obs., t. i.

[3] Lancet, 1850.

[4] Diseases and Injuries of Bones.

[5] Dublin Med. Journal, vol. vi.

Moreover, in occasional, perhaps in frequent instances of traumatic myelitis, the inflammatory process does not involve the whole thickness of the cord; it may be restricted to the central gray matter; and, possibly, to one of the columns. An instance in point is given by Anstie:—[1]

A woman, aged 38, fell thirty feet from a window, and came under Mr. Holt's care. There was a scalp wound, with "concussion;" paralysis and delirium. In eight days death supervened. The *autopsy* showed fractures of the sixth cervical vertebra and skull; red softening of the central gray matter of the cord; antero-lateral columns healthy. (Ashhurst.)

Another instance in point is given by Genest:—[2]

A woman, aged 40, received a blow on her back. Six weeks afterwards she felt pain starting from the right foot. Gradually the pain extended to various parts of the limb; and, after a month, it was accompanied by spasmodic contractions, and by diminished voluntary motion. She walked with great difficulty, even with the help of a stick. There was no alteration in the temperature of this limb. The convulsions extended to the other limbs and to the head, and the patient died. *Autopsy.*—Brain normal; cerebellum a little softened; no meningitis; spinal cord healthy, excepting at the swelling for the lower limbs, which, for an extent of eighteen lines and a depth of one line, on its posterior aspect, was softened, and looked like cream, somewhat rose-colored. The softening in this case was obviously inflammatory, and was restricted to the posterior columns. This circumstance is also instructive as well as interesting, because the morbid action was engendered by concussion (contusion) of the cord substance.

To briefly enumerate the *morbid appearances* which result from traumatic myelitis: they are (1) red softening; (2) purulent infiltration of the reddened and softened rachidian substance; (3) collections of purulent matter (abscesses) surrounded by areolæ of red softening, one or two lines thick, in the rachidian substance; (4) more or less complete liquefaction of the cord, but without well-defined margins. The morbid appearances usually extend through the whole thickness of the cord, and some considerable distance in a longitudinal direction, but mostly upward; occasionally, however, they are restricted to the central gray matter, or to the columns.

Etiology.—Traumatic inflammation of the spinal cord may arise from any wound which penetrates the spinal canal. It is often caused by simple fractures and dislocations of the spinal column, as well as by those that are compound. It is not unfrequently produced by concussions of the spinal cord, especially those that are attended by ecchymosis of the cord-substance; in such cases, the inflammatory process is apt to be subacute and to pursue a chronic course.

Dr. Nairne,[3] however, has recorded an acute case occurring in a lad, aged 17, in whom it was caused by severe jolting in a cart. Next day he was unable to walk, from paralysis; he rapidly grew worse; and, after ten days, he died. On *autopsy*, the spinal veins were found to be greatly congested; and a portion of the spinal marrow opposite the third and fourth dorsal vertebræ, at least one inch in length, was thoroughly disorganized and reduced to a semi-fluid state.

Occasionally, traumatic myelitis results from violent strains of the spinal column, although the bones and ligaments are apparently uninjured.

Sir W. Gull[4] relates the case of a man, aged 25, employed as a laborer in the commercial dock, who felt a sudden pain in the back after lifting some deals, on November 22. He walked to his home (about a mile and a half); was apparently well on the following day. Next morning (November 24), on waking, the legs were paralyzed. On the 26th, he entered the hospital. There was complete paraplegia, a bed-sore had already begun to form over the sacrum, and ammoniacal urine dribbled from the bladder. He died exhausted, on January 2, forty-one days after the strain.

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[1] Trans. Lond. Path. Society, vol. x.

[2] Brown-Séquard, op. cit., p. 72; quoted from Gazette Médicale de Paris, 1831, p. 34.

[3] Medico-Chirurgical Transactions, vol. xxxiv. p. 37.

[4] Guy's Hospital Reports, 1858, pp. 189, 190.

Autopsy.—A large bed-sore exposed the sacrum in its whole length. The bones and ligaments of the spine exhibited no trace of injury. The cord was softened, opposite the fifth and sixth dorsal vertebræ, through all its columns, into a thick, greenish, muco-puriform fluid, with a brown tinge. Lumbar and cervical portions of the cord normal. Commencing suppuration in the cortical substance of the kidneys. Mucous membrane of the pelves greenish, with patches of greenish fibrinous exudation. Mucous membrane of the ureters and bladder in the same condition; the bladder contained a quantity of muco-purulent fluid. The microscope showed the softened part of the cord to consist of disintegrated nerve-tissue, with a few irregular collections of granules.

Prognosis.—The outlook in cases of traumatic myelitis is always gloomy. From inflammatory disintegration of the spinal cord, gangrenous bed-sores often arise; and they prove fatal, not unfrequently, by inducing septicæmia or pyæmia, as happened in the following instance:—

A soldier was wounded at Antietam, September 17, 1862, in the lumbar spine, and lay on the field until the 20th, when he was taken to general hospital. At that time he could walk, but paralysis soon supervened. Retention of urine lasted two days; no difficulty afterward; no derangement of the alimentary canal; pulse small and weak; face flushed. The patient suffered greatly from bed-sores. On October 6 he suffered great pain in the legs; they were without feeling, but warm. On the 10th, profuse sweats occurred; he sank rapidly, and died on the 11th, apparently of septicæmia arising from the bed-sores. A conoidal ball was found to have passed through the spinal column and cauda equina at the third lumbar vertebra, and to have lodged at the left intervertebral foramen; condition of cord and membranes not reported.[1]

Again, traumatic myelitis may destroy life by causing vesical and renal inflammation, as well as an alkaline state of the urine. But the discussion of this point is reserved for the section on Disorders of the Urinary Organs arising from Lesions of the Spinal Cord.

Most frequently, however, traumatic myelitis ends in death by ascending the spinal cord until it involves the origins of the spinal nerves upon which the respiratory movements depend, when paralysis of the respiratory muscles and death from asphyxia (apnœa) ensue. Stromeyer mentions a case in which the posterior parts of the fifth and sixth cervical vertebræ were torn away by a bullet, and which ended fatally on the fifth day from this cause. Paralysis of the lower extremities occurred on the first day; afterward, complete paralysis of the arms, etc., was superadded.[2] I have already presented many examples in which death resulted in the same way, that is, by paralysis of the respiratory muscles in consequence of ascending myelitis. In the following example, where the cauda equina was injured, death appears to have been caused in the same manner:—

A corporal, aged 26, was wounded by a conoidal musket-ball, July 9, 1864, in the lumbar region, and on the next day entered general hospital. Three days after that, incomplete paraplegia set in. He suffered at times from excruciating pains at the seat of the wound and in the lower extremities. Anodynes were freely given. Sphincter ani muscle paralyzed; patient delirious at times; pulse slightly accelerated. Death resulted on the 18th. *Necroscopy.*—The missile had entered at a point midway between the anterior and posterior spinous processes (upper) of the ilium, one inch below the crest, passed inward and backward, chipped the sacrum at its posterior superior angle, fractured the fourth lumbar vertebra, and lodged in the spinal canal; condition of the cauda equina and membranes not reported.[3] The symptoms clearly indicate that this also was a case of ascending myelitis. Paraplegia beginning some days after the injury was inflicted, and then gradually extending upward, with incontinence of feces and urine, delirium, and diaphragmatic breathing, are signs quite characteristic of this affection when it spreads from the lumbar, upward to the cervical region.

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[1] Medical and Surgical History of the War of the Rebellion, First Surgical Vol., p. 446.

[2] Op. cit., p. 37.

[3] Med. and Surg. History of the War of the Rebellion, First Surgical Vol., p. 447.

In respect to disordered sensations, it should be observed that the excruciating pains in the wound and lower extremities which this patient endured, arose from the spinal meningitis which attended the inflammation of the cord-substance. But patients having acute traumatic myelitis often make no complaint of pain whatever during the whole course of the disease. A case in point is related on page 777, in which the cord was severed by the missile (Fig. 783); and although the upper portion of the cord was much softened by the inflammatory process, there was no complaint of pain. Sir W. Gull's case of acute myelitis, arising from a strain of the back (related above), likewise shows that the spinal cord may be completely destroyed for a considerable distance by the inflammatory process without causing much if any pain; for, in that case, no pain whatever was complained of, excepting the pain which attended the strain itself.

Among the symptoms which are particularly bad as prognostics in cases of traumatic myelitis, we may mention gangrenous eschars over the sacrum that are rapidly enlarging, inflammations of the kidneys or bladder that are rapidly extending, ascending paraplegia—paralysis of the upper extremities appearing some days after that of the lower extremities, etc., has occurred—and diaphragmatic breathing, especially when the latter is attended by dyspnœa and bronchial râles, for then the end may be quite near.

But, although the prognosis of traumatic myelitis is generally unfavorable, we are still not entirely without hope during the first stage of the disease; for, in the case of the cavalryman, aged 35, whose death suddenly resulted from hæmoptysis the case is related on page 817), the disease was shown by the necroscopy to be undergoing resolution; and in the *foudroyant* case of traumatic spinal meningitis related on page 808, potassium iodide and ergot were administered with a notably good effect upon the inflammation (acute hyperæmia) which attended the injury of the cord-substance, and preceded the inflammation of the spinal membranes.

Treatment.—Stromeyer says: "In a case where a bullet, entering laterally, bruised the third and fourth cervical vertebræ severely, and was not extracted, death resulted from the advance of inflammation of the spinal cord and brain; there was at first paralysis of the arm belonging to the injured side; it was followed by incomplete paralysis of all the limbs, ending in coma. Antiphlogistic treatment had been entirely neglected."[1] The patient afflicted with acute traumatic myelitis should always be placed on a water bed. In other respects the prophylaxis and treatment of this disease are the same as for traumatic spinal meningitis (see page 814).

For an account of the prophylaxis and treatment of sacral eschars (so-called bed-sores), and of vesical and renal inflammations which result from myelitis, the reader should consult the sections specially devoted to those topics.

In regard to the treatment of chronic myelitis with paraplegia, I will briefly mention a case which was successfully managed by Dr. C. Taylor.[2] The disease had lasted eleven months before the treatment was commenced. This consisted in the administration of ergot and belladonna, potassium iodide, and cod-liver oil, with alternated cold and hot flapping of the back, twice daily, and a cold douche followed by violent rubbing with mustard every morning. Complete recovery, excepting some slight want of ability to guide the legs, was obtained. The symptoms were very well marked; the treatment was, therefore, founded on an accurate diagnosis. It will also be remembered that belladonna (per orem) gave notable relief to vesical and urethral hyperæsthesia in one of the cases related above. In at least three instances belonging to the same category as Dr. Taylor's patient, I have seen much benefit derived from the fluid extract of ergot and potassium iodide. In one case where there probably was constitutional (tertiary) syphilis, corrosive sublimate (gr. $\frac{1}{16}$ thrice daily) did good. Concerning belladonna, Brown-Séquard justly remarks that no other medicine known has so much power to diminish the reflex faculty of the spinal cord.[1] Nux vomica and strychnia are never admissible in the treatment of this disease, because they increase the amount of blood in the cord.

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[1] Op. cit., p. 38.

[2] British Med. Journal, May 24, 1862.

Sacro-Gluteal Eschars, and other so-called Bed-Sores, arising from Lesions of the Spinal Cord and Spinal Nerves.

These affections so often present themselves in cases of spinal injury, and usually give so much trouble to both surgeons and attendants, as well as to patients, whenever they do appear; and finally, they prove so frequently to be the proximate cause of death in fatal cases of spinal injury, that a special consideration of them is demanded in this place. There are two important varieties of these eschars or sores which are met with in cases where the spine is injured; and they differ very widely in respect to their causation, the gravity of their prognosis, and the remedial measures that are necessary. These distinct kinds or varieties of bed-sores are: (1) the *common*, or that which is often met with in cases where there is no spinal injury nor spinal disease, as well as in cases where the spinal column is injured; and (2) the *neurotrophic* or *neuropathic*, or that which arises from some morbid excitation or disease of the spinal cord or spinal nerves. The former has long been known; the latter was first described by M. Brown-Séquard.

(1) The *common* kind of bed-sore is liable to occur in all injuries or diseases which are attended with inability on the part of patients to move themselves or change their positions in bed; for instance, in certain fractures of the femur, and in certain forms of disease or injury of the hip-joint, etc., as well as in fractures and dislocations of the spinal column. In such cases the patients, unless properly cared for by others, will continue to lie in one settled or unchanged position all day, and all night, perhaps for several days and nights together. Hence, the whole weight of their hips will press with concentrated energy upon the integuments which cover the most projecting points of their pelves. The skin and fasciæ overlying the superficial, convex, and irregular surface of the sacrum sustain the principal pressure. That compression interrupts the circulation; the blood which ought to enter the compressed tissues is prevented from doing so; the blood already there is squeezed out; the vessels are tenantless. An additional evil remains; it is almost impossible, with even the greatest care, to prevent some urine, perhaps but very little, from trickling into the bed-clothes or down the private parts. Furthermore, in spite of every attention, the fecal discharge lodges about the anus, to greater or less extent, and gets mixed with the urine. The integuments of the nates may become macerated in this stinking mixture, and then its liquid portion will act on the sodden tissues like an escharotic substance. It is, therefore, not surprising that the integuments covering the sacrum, etc., when subjected to the destructive influence of pressure too con-

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[1] Op. cit., pp. 175, 176.

stant or long continued, combined with that of decomposing urine and feces, should soon become converted into an eschar, a slough, or a bed-sore. For a further account of the common variety of bed-sore—of its symptoms and treatment—the reader is referred to Prof. Moore's Article in the Second Volume of this Work, pp. 306-308.

(2) The *neurotrophic* or *neuropathic* variety of bed-sore appears to have been clearly understood for the first time by M. Brown-Séquard, as already intimated, for he first demonstrated by experiments on animals the peculiar nature, as well as the causal relations and causal indications for treatment, of this important lesion. The celebrated Dr. Bright, however, had already been so much struck by its chief clinical features that he caused drawings and models in wax illustrating them to be prepared; and he, likewise, related four examples in point in his "Reports of Medical Cases."[1] But M. Brown-Séquard, after prolonged research and reflection, and after making numerous experiments on animals, to elucidate this lesion, remarked concerning it, in 1858, as follows:—

"The production of sloughs on the sacrum cannot be considered as an effect of prolonged pressure [from the decubitus] upon the parts of the skin where they appear, [inasmuch] as they sometimes are produced in a few days and even in a few hours after the fracture. They result from a *morbid excitation* of the spinal cord, and not from the *loss of action* [*paralysis*] of that nervous centre owing to its partial or complete section, as I have proved by experiments [on animals] showing that they never occur after [simple] section of the cord. The proof that pressure upon the sacrum has but a slight influence in their production, is clearly given in the case of animals on which, after fractures of the spine, I have seen sloughs occurring in parts that were not subjected to pressure. Besides, it is known that men who are confined to bed by other causes than a nervous complaint, may bear pressure upon the same part of the body for a long time without producing sloughs. Pressure upon the sacrum is, therefore, only an additional cause of sloughs. For the mode of action of the nervous system in producing alterations of nutrition, I will refer to my lecture on the influence of the nervous system upon nutrition,[2] and I will only say here that an irritation, and not a paralysis, is the cause of these morbid changes."[3]

Among the points established in the lecture to which he refers, are the following:—

(1) The phenomena of reflex action, that is, pains and muscular contractions in the peripheral parts, can also be produced by directly irritating either the spinal cord as a compound nervous centre (that is, a series of nervous centres arranged one above another), or the spinal nerves which issue from it.

(2) "The phenomena of this *direct* irritation have very often been mistaken for consequences of the absence of action in the nervous centres. I will merely point out here the rapid sloughs that are observed after fractures or luxations of the vertebral column, and the rapid change of the urinary secretion in similar cases."[4]

(3) "I will only add, as regards the influence of the pressure on the spinal cord producing sloughs on the nates and other morbid changes, that it is

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[1] Op. cit., vol. ii. pp. 383, 423, Diseases of the Brain and Nervous System. London, 1831.

[2] For more details on the capital point that it is chiefly owing to a morbid action of the nervous system that alterations of nutrition take place in diseases of that system, and not, as generally supposed, to a paralysis, that is, to a cessation of the action of that system, see *Journal de Physiologie*, 1859, p. 112.

[3] Brown-Séquard's Lectures on the Physiology and Pathology of the Central Nervous System, etc., pp. 248, 249.

[4] Ibid., p. 176.

chiefly in exciting a persistent contraction of the bloodvessels in the parts where nutrition or secretion is morbidly altered, that the pressure on the cord acts. As it often happens that death, after a fracture or a luxation of the spine, is due to the slough formed on the nates, I think I must remark that a very good means of dilating the bloodvessels consists in exhausting their irritability by applications of powerful galvanic currents."[1]

"To complete the demonstration of the proposition that death after fracture of the spine is usually due to the effects of the excitation of the spinal cord by pieces of broken bone [by ecchymosis from contusion of its substance, and by inflammation of its substance], and not to the results [merely] of a partial or complete section of this nervous centre, we will only say that there are many cases on record showing that a section or even a crushing of the spinal cord has not proved fatal [in man], and that in animals death is rarely caused by a partial or complete section of the cord in the dorsal region, while they die as quickly and as often as men after a fracture of the spine, if the broken pieces be not removed [and if myelitis, etc., be not prevented]."[2]

There is no doubt, then, that the eschars in question result not from mere *division* of the cord-substance, whether partial or complete, but from *morbid excitation* of that substance arising either from the irritation that is caused by the contact of foreign bodies, *e. g.*, splinters of bone and extravasations of blood, or from the inflammatory process acting upon its histological elements, when it is aroused by the injury.

This remarkable affection of the parts situated at the peripheral extremities of the spinal nerves, which results mainly from central causes, Samuel has proposed to characterize by naming it *Decubitus Acutus*, and Charcot has accepted the appellation.[3] Nevertheless, this term is far from being satisfactory, *first*, because the term "decubitus" is commonly applied to the posture of the patient in bed, which has generally but a small share in the production of the disease; and, *secondly*, because in some strongly marked examples on record, the "decubitus" has had nothing whatever to do in causing the peripheral gangrene, as, for instance, in the following highly instructive case, which has already been several times referred to:—

The late Dr. D. S. Conant[4] presented to the New York Pathological Society, together with the osteological specimen, an account of an interesting case, in which the last dorsal and the first lumbar vertebræ were fractured, and the spinal cord severed by an osseous splinter from the laminæ of the first lumbar. Within six days after the casualty, an immense, gangrenous blister formed on the inner side of each thigh without any apparent cause.

A stout man, aged 55, was blown off from the rigging of a ship on which he was at work, by a high wind, on a certain Monday. He hit something in his descent and turned over, but finally struck heavily upon his shoulders. When taken up by his comrades, he was completely paralyzed in both lower extremities. Three days afterward, Dr. Conant saw him in consultation, and found that there was complete loss of sensibility and motion below a certain well-defined line extending around his body. There was also noticed a posterior angular deformity of the spine at the dorso-lumbar junction, and Dr. Conant diagnosticated fracture with crushing of the body of the twelfth dorsal vertebra, and with fragments of bone impinging upon the spinal cord. The patient went on very well until the Saturday following the injury, his mind remaining perfectly clear. On Sunday morning his physician noticed a large blister on the inner side of each thigh, and extending nearly the whole length thereof, unconnected with any previous local irritation. At four o'clock he had a chill, his mind till then having remained clear. But soon after be became delirious, and quietly died without any convulsions at seven o'clock the same evening, six days and some hours after the accident, apparently in consequence of septicæmia.

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[1] Ibid.

[2] Ibid., p. 250.

[3] Lectures on the Diseases of the Nervous System, translated by Dr. G. Sigerson, p. 57. Philadelphia, 1879.

[4] American Medical Times, June 1, 1861, pp. 359, 360.

Autopsy.—There was a considerable quantity of extravasated blood on each side of the spinal column, in the vicinity of the last rib. The body of the last dorsal vertebra was found crushed, and a little piece of bone from the laminæ of the first lumbar vertebra had cut the spinal cord entirely off. The blisters on the inner sides of the thighs were found to be the results of mortification. The internal organs were all healthy. No statement is reported as to the presence of a sacro-gluteal eschar, but without doubt there was a large one formed by Saturday, when it was noted that the patient was not doing so well. It is mentioned that there was but little disturbance of the pulse, notwithstanding that mortification was occurring in the lower extremities. The textural condition of the spinal cord, aside from its complete division by a fracture-splinter, is not described. The gangrenous inflammation of the thighs was thought to be due to "injury of the sympathetic ganglia situated at the angles of the last two ribs." But, inasmuch as in other cases belonging to the same category, similar eschars have appeared when vaso-motor paralysis has been completely wanting, it is only fair to infer that in this case the gangrenous lesions of the thighs arose from morbid excitation of the spinal cord, which is merely another name for traumatic myelitis, at least in this particular instance.

Again, in the following example of *chronic myelitis* arising from concussion of the spinal cord, at the lower part thereof, where the resultant paraplegia was very far short of being complete, an ulcer or slough of large size presented itself in the integuments over the sacrum, although there had been no absolute confinement to bed at any time:—

Professor Wm. A. Hammond[1] relates the case of an originally healthy married woman, aged 22, admitted into the Baltimore Infirmary, on March 14, with chronic myelitis, the result of an injury. She was a sober, intelligent young woman, by occupation a weaver, four years married, and the mother of a child then three years old. She had always been healthy until her present illness, excepting that in girlhood she had been affected to some extent with rheumatism and occasional epistaxis.

Eleven months before admission, whilst in a somnambulistic state, she fell from a second-story window, and struck the hand-rail of a porch in her descent, injuring her back about the junction of the lumbar vertebræ with the sacrum. The immediate consequences were pain in that region, soreness across the abdomen, and the passage of bloody urine. For seven months catheterization was necessary, after which time the bladder in a measure recovered its contractility, but soon lost it again, the sphincter also becoming paralyzed. Severe cough likewise ensued; and the catamenia, heretofore quite regular, entirely ceased. There was slight paralysis of the lower extremities from the time of the accident, which gradually increased until considerable difficulty was experienced in walking, or even in standing. There was also deficient sensibility in both lower extremities, and likewise over the sacral region. Soon after the accident, the sphincter ani lost its power. From the first, she experienced more or less numbness and spasm in her lower extremities. She had been treated by cupping the lumbar and sacral regions, and by strychnia.

At the time of admission, there was complete paralysis of the sphincters of the bladder and rectum. Her urine was constantly flowing from her, and the moment her feces entered the rectum it was evacuated. Upon introducing a finger into the bowel, it was found to be entirely relaxed; and, in fact, three or four fingers could be inserted with ease. Her lower extremities were partially paralyzed. Although she could still walk, she did so with difficulty. Frequent cramps and almost constant formication were present, and there were occasional startings of the limbs without her being aware of them. There was a good deal of pain in the sacral region; and, as is usual in such cases, a large ulcer existed in the same locality.

On applying the æsthesiometer to the anterior surface of her legs and thighs, to those parts which are supplied by branches of the lumbar plexus of nerves, there was no diminution of sensibility found. She appreciated the two points when separated only to the extent of half an inch. But, on applying the instrument to the posterior surface of her legs and thighs, to the parts which are supplied by the sacral plexus, she was conscious of but one impression. Even when the points were separated to the extent of five inches, but one impression was perceived; and, over the gluteal and sacral regions, she could not feel them at all. It was therefore evident that the disease affected the portion of the spinal cord from which the sacral plexus arose—namely, the lower portion. In addition, it was found that the sphincters of the bladder and rectum, which likewise derive their nerve-filaments from the same plexus, had lost their contractile power. There was a sense of constriction also present, and the urine was strongly alkaline.

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[1] American Medical Times, June 15, 1861, pp. 379–381.

The *diagnosis* of chronic myelitis was founded on the fact that for a long time the patient had experienced constant pain at the point where the healthy and diseased portions of the cord united; that there was a sense of constriction also present there; that there was a feeling of numbness almost constantly present in the paralyzed portions of her body; and, frequently, other morbid sensations, such as coldness, burning, formication, etc.; that there were oftentimes reflex-motor spasms in the lower extremities; that there was well-marked anæsthesia in the portions of cutaneous surface supplied by nerves issuing from the diseased part of the spinal cord; that the sphincters of the anus and bladder were paralyzed; that the normal movements of the lower extremities were considerably impaired; that there was a large slough over the sacrum; and that the urine was strongly alkaline.

The *treatment* consisted in administering ergot in moderate doses by the mouth, and belladonna by the skin, by applying thereto a large plaster made of that remedy; fresh air, moderate exercise, and a good, nutritious diet were also enjoined. The sacral slough was treated by the method recommended by M. Brown-Séquard (which will presently be described), and by applying galvanism.

May 16. The patient has recovered full control over the bladder, the rectum, and the extremities; her ability to walk is also very much improved. The slough over the sacrum has been entirely cured. The pain has almost entirely departed from the cord, and she is no longer troubled with cramps or numbness in the lower extremities. This highly beneficial plan of treatment is to be continued until the cure is complete.

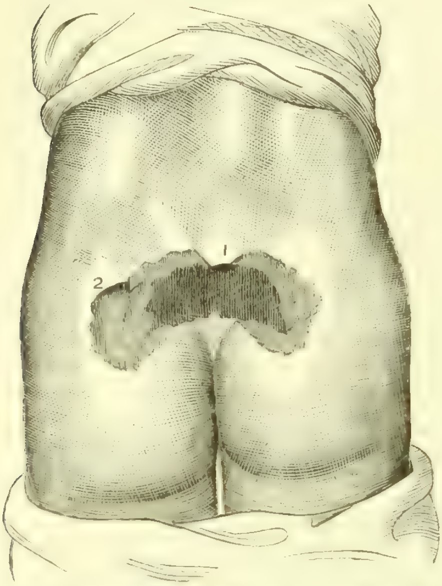
The history of this exceedingly instructive case I have presented as briefly as seemed consistent with elucidating in a satisfactory manner the symptoms, the diagnosis, and the therapeusis of this sometimes obscure and often very troublesome disorder of the spinal cord; and by so doing I have really saved the use of many words and even paragraphs in the way of abstract description, which ultimately would have been required.

Thus I have presented two important examples in which the patient's "decubitus" had no part whatever in the production of the eschars in question, and in the latter of them the eschar was not even "acute." It is, therefore, quite evident that the term "decubitus acutus" is not at all appropriate for such instances, as well as not particularly appropriate for any instance of the lesion under consideration; and with a view to indicate at the first glance the nervous origin of these sloughs, I have ventured to call them *neuropathic eschars*, that is, eschars which arise mainly in consequence of morbid excitation or disease of the spinal cord itself, or of the spinal nerves that supply the parts on which the eschars are formed.

Symptoms of Neuropathic Eschars.—The first sign of this disorder is an erythematous patch on which vesiculæ and bullæ are rapidly developed; mortification of this patch of the skin and subjacent tissues very often ensues.

When this disorder appears in consequence of a lesion of the spinal cord, it usually presents itself in the sacral region. Here it is bisected vertically by the median line; and it extends itself symmetrically, on either side, into the adjacent integuments. (Fig. 795.) But it may likewise appear on almost any part of the trunk or the members that may be subjected, by posture, to a somewhat continuous pressure. In certain cases, a very slight and a very short pressure suffices to determine its appearance. Finally, there are some cases, the number of which is probably not very great, wherein it seems to be produced without the intervention even of the least degree of pressure, or of any other cause of a similar kind. I have just presented two very instructive examples belonging to this category.

Fig. 795.



Showing a sacro-gluteal eschar of neuropathic origin, which was formed in a case of myelitis involving the dorsal portion of the spinal cord: 1. The mortified part. 2. The erythematous zone. (Charcot.)

This disorder is quite distinct from the various cutaneous eruptions which are seen not unfrequently in the sacral region of patients condemned by different affections to long maintain a recumbent posture in bed. These eruptions, which sometimes are erythematous and lichenoid, sometimes pustular and ulcerous, sometimes papular, and having a deceptive resemblance to syphilitic sores (*plaques muqueuses*), are generally caused by repeated and prolonged contact with irritating substances, such as decomposing urine and fecal matter. They, as well as the neuropathic erythema and blebs, may become the starting points of genuine eschars, as already stated above. But the neuropathic eschar is often distinguishable, clinically, from that of the former, by certain important characteristics, namely: (1) By appearing shortly after the primary disorder of the nerve-tissue, or by following upon a sudden exacerbation of that disorder; and (2) By exhibiting a very rapid evolution. (Charcot.)

Some days, or, it may be, only some hours, after the causative affection of the spinal cord has manifested itself in such cases, there appear on certain portions of the skin, already mentioned, one or several erythematous patches, variable in extent and irregular in shape. The skin here has a rosy hue; sometimes, however, it is dark-red, and even violet, but still the color disappears momentarily on making pressure with a finger. M. Charcot has ascertained that in such cases the derma is, anatomically, infiltrated with leucocytes, as happens in erysipelas.[1] Occasionally, but, for the most part, in examples of myelitis, there-appears besides an apparently phlegmonous tumefaction, involving the derma and subjacent tissues, which may be attended by acute pain, if the affected part have not been previously stricken with anæsthesia.

In a day or two, but sometimes sooner, vesicles or bullæ make their appearance about the middle of the erythematous patch; they contain a liquid substance or serosity, which is sometimes colorless and perfectly transparent, and sometimes more or less opaque, reddish, or of a brownish hue.

If the causative affections of the spinal cord or spinal nerves now abate, the vesicles and blebs soon wither, dry up, and disappear. Sometimes, however, the blistered epidermis becomes torn, drops off in pieces, and lays bare a bright-red surface strewn with violet points or patches, corresponding with a sanguinolent infiltration of the cutis vera. In such cases, the subcutaneous connective tissue, and sometimes even the subjacent muscles, are likewise invaded by the sanguinolent infiltration. This fact M. Charcot has repeatedly verified by post-mortem examination.[2]

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[1] Op. cit., p. 58, foot-note.

[2] Ibid., p. 58.

These violet-colored points or patches of sanguinolent infiltration rapidly widen, and soon their edges run together or coalesce. Thus, in a short time, there supervenes in the affected part a mortification of the cutis vera, which is at first superficial, but soon becomes profound, and may involve not only the subcutaneous connective tissue, but likewise the subjacent muscles, and even the subjacent bones. Thus the eschar is constituted in the neuropathic cases under consideration. If there be some chance for a favorable issue still remaining, the work of reaction against, and elimination of, the mortified tissues at once begins; and, should the prospect become more favorable, a period of reparation will follow, which, however, is liable to exhibit many fluctuations in its course.

It should have been stated that in cases of typhus and typhoid fever, a cutaneous affection of the sacro-gluteal region, etc., not unfrequently occurs, which bears a strong resemblance to the neuropathic bed-sore now under consideration, and which, perhaps, arises in part from analogous conditions. This cutaneous affection of the buttocks, in typhus and typhoid fevers, has been minutely described by Piorry, in France, and by Pfeüfer, in Germany.

In the production of neuropathic bed-sores, the patient's posture in bed often plays an important part. For instance, it is not unusual in cases where the patient is so placed as to repose on his side, during part of the day, to find, in addition to the sacral eschar, large necrotic ulcerations occurring over the great trochanters. It is also quite common to see in cases of spinal injury attended with paralysis, that the different parts of the paralyzed limbs which are exposed to only slight and brief pressure, such as the ankles, heels, and inner surfaces of the knees, present lesions characteristic of neuropathic bed-sores. On page 675 (*supra*), I have presented, with a wood-cut (Fig. 765), an abstract of the case of a soldier whose spinal cord was severed by a knife opposite the fifth cervical vertebra; neuropathic sphacelus soon followed, attacking all the projecting points on the lower part of his body, and proceeding rapidly until it almost bared the sacrum. In some rare instances, I have also seen neuropathic eschars present themselves over the scapulæ and over the olecranon process.

Clinical Relations.—In the foregoing pages I have mentioned or referred to a great many cases in which neuropathic eschars appeared in connection with fractures or dislocations of the vertebræ, and consequent injury of the spinal cord. In regard to the time when the symptoms of neuropathic eschars are most likely to present themselves in cases where the spinal column is injured, Dr. E. Gurlt, whose opinion on this subject is based on the study of a very large number of cases, holds that the first symptoms of this affection usually appear from the fourth to the fifth day after the accident. But the initial erythema and bullæ may appear very much earlier than that; for, on page 721 (*supra*), I have presented, with a wood-cut (Fig. 772) illustrating the vertebral lesion, the case of a soldier who dislocated the fourth cervical vertebra with much displacement and much damage to the spinal cord, in a vain attempt to turn a somersault, and who survived the accident only forty-four hours; nevertheless, it was found at the autopsy that "ulceration over the sacrum had already commenced;" that is, a well-marked bed-sore was already formed. In this case, then, the initial erythema and vesicles or blebs must have presented themselves within a few hours after the accident.

The initial symptoms of a neuropathic eschar on the breech appeared in less than thirty-six hours after the injury, in a case under the late Dr. James R. Wood's care, at Bellevue Hospital:—

The patient was a stableman, aged 30, who fractured the seventh cervical vertebra by falling down stairs, at 7 P. M., on June 13. He was insensible for the moment.

On the 14th, at 6 P. M., he was admitted to the hospital, with complete motor and sensory paralysis of the entire body, below the third rib in front and the fourth rib behind. The decubitus was dorsal, with head and neck thrust forward. The respiration was purely abdominal (diaphragmatic). The penis was strongly erected. Neither urine nor feces had been passed since the accident.

On the 15th, A. M., a red spot, nearly two hands' size, was observed upon the left nates, and vesication in the fissure near the extremity of the coccyx. In the evening, marked increase of temperature all over the surface of the body was found, and a purplish spot, the commencement of a slough, low down in the cleft of the nates.

On the 16th, A. M. A purple spot commencing over the third or fourth lumbar vertebra; some hæmaturia; and considerable tympanites. 7½ P. M. Great dyspnœa; bronchial tubes and trachea filled with secretion.

On the 17th. The incipient bed-sores no further developed; patient delirious at times through the day. 7 P. M. Entire anæsthesia and paralysis of both arms—they were not paralyzed early in the afternoon; great tympanites; urine high-colored; priapism always induced by passing the catheter; was conscious and sane. 9 P. M. Comatose and insensible; eyes suffused; convulsive movement of lower jaw; body still hot; pulse full and strong. 11¾ P. M. Died quietly, comatose, and without general convulsions, four days plus four and three-fourth hours after the accident. *Autopsy.*—Body of seventh cervical vertebra fractured transversely and completely; ligamenta subflava completely disrupted; the vertebra dislocated; spinal cord not lacerated; brain moderately congested. Pathological condition of the cord not described.[1] The ascending and deepening character of the paralysis, however, denotes, under the circumstances, that there was ascending myelitis.

In a case related on page 796 (*supra*) the initial symptoms of neuropathic sphacelus simultaneously occurred at several different points in the lower extremities, in less than twenty-four hours after the spinal lesion:—

The patient was a derrick-man, aged 41, admitted to Bellevue Hospital, in Dr. Stephen Smith's service, two hours after he had sustained a fracture of the tenth dorsal vertebra, with complete paraplegia, in consequence of being thrown from a cart and striking his back upon the stony street. Next morning it was observed that sloughs had commenced to form upon the heel and upon the ball of the great toe of his left foot, and over the external malleolus of his right ankle, without any apparent cause; several hours afterwards, death ensued in consequence of compression of the spinal cord by extravasated blood.

In a case recorded by Dr. L. Buchner, of Darmstadt, in which a man, aged 46, had sustained complete diastasis of the sixth and seventh cervical vertebræ by falling from a height, and in which death supervened sixty hours after the accident, a well-marked bed-sore of spinal origin was already visible. (Gurlt.)

It has been claimed by many that *anæsthesia* is an essential factor in the causation of bed-sores having a spinal origin. This view, however, is negatived by the case of a young woman, aged 22, related by Professor Hammond, which I have presented on page 826; for, in that case, a large sacral eschar appeared, although the patient had never been confined wholly to bed, and had never been entirely unable to walk; and, therefore, of course, had never had complete paraplegia, nor anything like profound anæsthesia.

This view is also negatived by an example of vertebral fracture reported by Jeffreys:—[2]

The patient was a man, who was injured by a fall of twenty-five feet from a ladder. There was much shock, with a cold skin, and a barely perceptible pulse. All the parts below the fracture were deprived of sensibility and voluntary motion. Next day there was persistent priapism; "then supervened phlyctenæ in the region of the sacrum;" and, on the same day, "the patient recovered his sensibility." Death, however, ensued; and, on post-mortem examination, it was found that the bodies of the seventh and eighth dorsal vertebræ were broken into several pieces, which were much displaced.

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[1] New York Journal of Medicine, January, 1859, pp. 85–87.

[2] London Medical Journal, July, 1826.

In a case where neuropathic eschars appear, priapism, strong alkalinity of the urine, hæmaturia, inflammation of the urinary bladder or kidneys, hyperæsthesia, vaso-motor exaltations or depressions of the body-heat, clonic convulsions of the paralyzed members, tonic (that is, tetanoid) spasms occurring in paroxysms, in brief, all those symptoms which usually reveal an excited state of the spinal cord and spinal membranes, often precede, accompany, or closely follow the formation of these eschars.

When the injuries (traumatisms) or the secondary lesions which excite the spinal cord in cases where neuropathic eschars ensue, affect the cord symmetrically, the eschars themselves, as a rule, are symmetrically developed, as shown by Fig. 795; as also happened in Dr. Conant's case, where a large gangrenous eschar, of an equal size, presented itself on the inner side of each thigh; and as in Dr. Stephen Smith's case, referred to above, where sloughs of similar size and appearance simultaneously formed on each foot and ankle, in consequence of spinal injury. But, when the traumatism affects one side only of the spinal cord, then the neuropathic eschars which arise therefrom are not symmetrically developed; they are found only on the side of the body opposite the side of the cord which is injured or diseased. For example, in the case of a man admitted into Professor Nélaton's ward at the St. Louis Hospital, for a sword-wound of the back dividing the left half of the spinal cord (I have already presented a pretty full account of this case on page 800), "a slough formed on the right side of the sacrum, although the patient had not felt anything there." The man, however, recovered. The same peculiarity has been observed in several analogous cases; and, according to M. Brown-Séquard's experiments, it is a constant fact in the case of animals.

The information derived from M. Brown-Séquard's experiments in this regard, is capable of giving so much practical aid or useful help to surgeons in diagnosticating spinal lesions and spinal disorders, that I will briefly refer to them in this place. We learn first from these experiments, that after wounds dividing one lateral half of the spinal cord, there supervenes in animals motor paralysis of the lower extremity on the same side as the lesion of the cord. This limb also presents exaltation of tactile sensibility (hyperæsthesia) in a more or less marked degree, and it likewise exhibits a notable elevation of temperature correlated with vaso-motor paralysis. But the opposite limb, on the contrary, retains the normal temperature and the normal power of motion, whilst its tactile sensibility is much lessened, or may even be extinct; that is, it exhibits anæsthesia and sensory paralysis. All these phenomena or symptoms are exactly reproduced in man under analogous circumstances. In his case, as in that of animals, we may also find various trophic derangements rapidly supervening in the peripheral parts of the body, which manifestly arise from the spinal lesion. Among the consequences of these trophic derangements I have already mentioned *bed-sores*, occurring not on the injured side, where the voluntary motor and vaso-motor paralysis is to be found, together with exaltation of temperature and hyperæsthesia, but on the opposite side of the body, particularly on the opposite side of the sacral region, that is, on the side where the motor functions, both voluntary and vasal, are unimpaired, and where there exists only a deadening of the sensibility, or anæsthesia. This circumstance clearly shows that neuropathic bed-sores do not arise from vaso-motor paralysis, as some persons have vainly imagined.

In man, other nutritive lesions of a similar character have been observed.

I shall here take space to mention only two of them, namely: (1) Rapid diminution of the faradic contractility of the muscles, soon followed by an equably rapid atrophy of the muscles themselves, or *acute muscular atrophy;* and (2) A peculiar form of joint-disease inflammatory in character, or *spinal arthropathy.* It is, however, a remarkable fact, that while the spinal or neuropathic eschar, in cases where the cord is partly divided, appears on the side of the sacrum opposite the spinal injury, the arthropathy and the muscular atrophy are to be found in the limb belonging to the same side as the spinal injury. For example, in the case of a man who was admitted into Professor Nélaton's ward with a sword-wound dividing the left half of the spinal cord (already twice mentioned), the symptoms showed rapid improvement up to the twelfth day after the casualty; on that day it was remarked that, without apparent cause, the *left* leg, still more sensitive than normal, had increased in volume, and that a quantity of fluid had accumulated in the left knee-joint sufficient to float the patella half an inch above the condyles. Two or three days subsequently, an eschar was observed occupying the *right* lateral part of the sacrum and the right gluteal region.[1]

Another very instructive example, which occurred in one of Dr. Cusco's patients, is related by M. Charcot, and I will present a brief abstract of it:—

> A man, aged 40, was stabbed with a poniard, in the night of February 15–16, 1871, at the third dorsal vertebra, and on the left side thereof. The weapon penetrated downward and toward the right, and divided the *left* half of the spinal cord. The left leg was immediately stricken with motor paralysis, while the right was not. He was at once brought to hospital. In the morning the following note was made: *Left* lower extremity, complete motor paralysis; limb perfectly flaccid; no trace of contraction, nor of rigidity; no spasmodic movements, nor subsultus. But its sensibility is greatly exaggerated; the least touch of the skin, especially near the foot, causes pain; pressure has the same effect; a slight pinch or a tickle is followed by very painful sensations; the application of a cold body produces painful sensations which the patient compares to prickings. *Right* lower extremity, the voluntary motions are all perfectly normal, but the sensibility is almost completely destroyed; complete analgesia; sensitiveness to touch almost null; the contact of a cold body causes an obscure, dull, prickling sensation. The insensibility is not restricted to the lower limb; it ascends to a level with the right nipple. The urine and feces passed involuntarily.
>
> On the 24th, it was noted that the left (motor-paralyzed) limb was warmer than the right; and that the patient complained of feeling constricted or compressed at the base of the thorax.
>
> On March 5th (seventeenth day), the patient complained of troubled sight: left pupil contracted more than right pupil; the vessels of left eye more numerous and voluminous than those of right eye. The evacuations, for the last two days, had again been voluntary. The state of the lower extremities remained unchanged.
>
> On the 13th (twenty-fifth day), the *right* buttock, since the day before, had been the seat of livid redness, and the epidermis had already fallen off from a part of the erythematous patch.
>
> On the 14th, the integuments on the *right* buttock, near the sacrum, were denuded to the extent of a crown-piece, and ecchymosed—that is, there was a *spinal bed-sore.* The *left* knee-joint was red and swollen, and likewise the seat of spontaneous pains, which were increased by moving the joint—that is, there was *spinal arthropathy.*
>
> On the 24th, an ulceration had occurred on the *right* buttock, on a level with the ecchymosed patch, which now was covered with granulations. The *left* knee was almost free from redness and swelling, as well as from pain.[2]

The following very instructive example of *acute muscular atrophy*, taken from Dr. W. Müller, is likewise presented by M. Charcot:—[3]

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[1] Brown-Séquard, Journal de la Physiologie, t. iii. p. 130.

[2] Op. cit., p. 70.

[3] Ibid., pp. 70, 71.

The patient was a woman, aged 21, who was stabbed with a knife in the back, at the fourth dorsal vertebra; the weapon, as the autopsy afterwards demonstrated, divided the *left* lateral half of the spinal cord, two millimetres above the third pair of dorsal nerves. On the first day, complete paralysis of motion and hyperæsthesia were observed in the *left* lower extremity; the opposite limb was anæsthetic, but not paralyzed. On the second day it was found that the muscles of the paralyzed member, and of the lower part of the abdomen, gave no reaction under faradic stimulation, whilst, in the corresponding parts of the opposite side, the electrical contractility continued normal. On the eleventh day, a neuropathic or spinal eschar was formed, which occupied the right sacro-gluteal region, and extended to the right gluteal eminence. It was also remarked, on this day, that the paralyzed limb had notably wasted away, and measured about two inches less in circumference than the anæsthetic member. On the thirteenth day, death occurred. At the *autopsy*, the borders of the spinal wound appeared tumefied, and of a reddish-brown color; a thin purulent layer covered it. Below the wound, the left lateral column presented the anatomical characteristics of descending myelitis, throughout its whole length.

Thus, we find that when the neuropathic or spinal bed-sore appears on but one side of the sacrum, or on one buttock only, in consequence of injury or division of the lateral column belonging to the opposite side of the spinal cord, the eschar is liable to be accompanied by a peculiar joint-disease of spinal origin, or by an acute muscular atrophy, also of spinal origin, which affections, however, both occur on the side opposite the neuropathic eschar—that is, in the lower extremity belonging to the same side as the spinal lesion. These clinical facts, and the intimate clinical connection which exists among these disorders when they are developed under the circumstances just mentioned, should be known to all surgeons.[1]

Continuing our inquiry into the clinical relations of neurotrophic or neuropathic eschars, we shall next find that they may arise from those forms of traumatic myelitis which are not attended by wounds of the spinal cord, nor by fractures, nor by dislocations of the spinal column. We shall likewise find that they may arise from this cause quite as rapidly as they would if the spinal column were also fractured. A case reported by Sir W. Gull, which I have already presented on page 820 (*supra*), clinically illustrates in a useful manner this mode of causation:—

The patient was a laborer, aged 25, who felt a sudden pain in his back, after lifting a heavy weight. On the morning of the second day afterward, his lower extremities were completely paralyzed. Two days later he entered hospital. A bed-sore had already began to form near the sacrum, and ammoniacal urine dribbled from the bladder." Death occurred forty-one days after the strain. *Autopsy.*—A large bed-sore had bared the sacrum in its whole length. The bones and ligaments of the spine exhibited no trace of injury. The spinal cord was disorganized by myelitis opposite the fifth and sixth dorsal vertebræ.

In this example of acute myelitis resulting from a strain of the back, the bed-sore began to appear within four days after the injury, and two days after the symptoms of myelitis had declared themselves. I have also presented on page 826, as will be remembered, the case of a woman, aged 22, reported by Professor Hammond, in which myelitis arising from concussion of the spinal cord, the result of a fall, was attended with the formation of a large sacral eschar.

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[1] There are, however, unilateral bed-sores also of cerebral origin—that is, bed-sores which arise from diseases of the brain, such as cerebral hemorrhage, cerebral embolism, cerebral softening, etc.—which appear on one cheek only of the nates, but they do not come within the scope of this article. I will merely remark here: (1) that the acute bed-sore which arises from cerebral diseases does not essentially differ from that which arises from spinal lesions (Charcot); (2) that the cerebral bed-sore can usually be distinguished with ease from that which is of spinal origin; and (3) that a full account of the genesis of cerebral bed-sores, illustrated with a wood-cut, is to be found in Charcot's Lectures on the Diseases of the Nervous System, p. 63.

But *spontaneous* acute myelitis, as well as *traumatic* acute myelitis, very often determines the precocious formation of sacral eschars, especially when it sets in suddenly and its evolution is rapid. Many instances belonging to this category have been placed on record by Gull, Duckworth, Joffroy, Engelken, Voisin, and Cornil, as well as by other observers.

We may also see a sacral eschar rapidly form in cases of spinal disease where the evolution is slow, should a new irritation of an active character suddenly intervene, or should an acute inflammatory process be suddenly superadded to the preëxisting lesion. Not only the exacerbations of partial sclerotic myelitis, but also the sudden invasion of the rachidian cavity by purulent matter emanating from an abscess, in the case of patients suffering from vertebral disease, may cause the rapid formation of sacral eschars. Should a tumor occupying the central part of the cord provoke the development of acute myelitis by its presence, the same result will follow. Several examples of this kind are on record. (Charcot.)

Neuropathic sphacelus of the integuments on the sacrum and nates may be caused by *traumatism of the cauda equina*, as well as by morbid excitation of the spinal cord itself. This important fact is proved by a case reported by M. Couyba,[1] and mentioned by M. Charcot:—[2]

A young soldier received a shot-wound at the outpost of Clamart. The missile entered his left side near the anterior extremity of the tenth rib, and emerged on the right side of the spinal column, about three inches from the spinous process, and on a level with the second lumbar vertebra. Paresis, with acute hyperæsthesia, of the lower extremities ensued. On the fifth day after the casualty, a bulla appeared on the right gluteal eminence, and quickly gave place to an eschar, which progressively extended so as at last to wholly cover the sacro-gluteal region. On the nineteenth day, death resulted.

Autopsy.—A layer of purulent matter covered the spinal cord, both anteriorly and posteriorly, from the cauda equina up to the cervical region. The cord itself, when examined, first in the fresh state, next in numerous hardened sections, did not exhibit any alterations. But a certain number of nerve-tubes in the nervous cords which form the cauda equina, presented the anatomical characteristics of fatty granular degeneration. Thus, the demonstration that a morbid excitation of the cauda equina had existed during life, was made complete. Additional examples of the same sort might be cited.

Finally, the morbid excitation of any peripheral nerve may be attended with the rapid formation of eschars in the integument belonging to its area.

For example, M. Charcot[3] relates the case of a woman at La Salpêtrière, who had an enormous fibroid tumor on the left side, which compressed, in the pelvis, the roots of the crural and ischiatic nerves of the same side. There had resulted a paretic state of the corresponding member, accompanied by acute pains running along the track of the principal nerve-trunks. One morning, shortly after the appearance of the first symptoms of compression, it was remarked that an eschar had rapidly formed on the left of and near to the sacral region. Likewise, on the left knee's inner surface some pemphigoid bullæ were found, in a spot which had been pressed upon by the right knee for a considerable time during the night, in consequence of the patient's attitude while asleep; these pemphigoid bullæ were filled with a brownish liquid, and soon gave place to an eschar. Nothing of the kind was developed on the right knee.

The fact that eschars of the integument may quickly form in consequence of morbid excitation of the spinal nerves which supply the peripheral areas where the eschars themselves appear, as occurred in the case just related, affords another good reason why the terminology of such eschars should be characterized by a name which distinctly recognizes their neurotrophic or neuropathic origin.

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[1] Thèse de Paris, 1871, p. 53, Obs. xiii.

[2] Op. cit., p. 75.

[3] Ibid.

Course and Consequences of Neuropathic Sphacelus or Eschars.—Should the disease spontaneously abate, or should the treatment prove successful, it may happen: (1) that the initial vesicles or blebs will wither, dry up, and leave a healthy surface; or (2) that the erosions, being superficial, will take on healthy action, granulate, and cicatrize; or (3) that the slough, although extending deeply, will become surrounded by a line of inflammatory demarcation separating the dead from the living tissues; that purulent matter will form throughout this line of demarcation, whereby the slough will become detached from the living tissues, so that it can be readily taken away by the surgeon; that the cavity thus formed will fill up by the granulating process; and, finally, that the space occupied by the slough, whether large or small, will become covered with new integument in the form of a cicatrix.

But not always, nor even in a majority of instances, is this fortunate issue obtained in cases of neuropathic sphacelus. On the contrary, this disorder often proves fatal, and that, too, in certain determinate ways, which I will now proceed to point out:—

(1) Occasionally, this disorder directly destroys life by causing *acute septicæmia.* That is, it sometimes happens in cases of neuropathic sphacelus that the eschars are very large, and at the same time do not become environed by any lines of inflammatory demarcation which plug with coagula the veins passing from the dead into the living tissues; wherefore these vessels remain open, and directly convey the decomposing blood, and putrid juices and putrid gases from the dead parts, into the general current of the circulation. Thus, septic poisoning of the blood, or septicæmia in its most acute form, sometimes occurs in cases of neuropathic sphacelus, and quickly destroys life. Without doubt this happened in the case reported by Dr. Conant, and already presented on p. 825, where a man had sustained vertebral fracture at the dorso-lumbar junction by being blown off from the rigging of a vessel while at work; for, on the morning of the following Sunday, a large blister of mortification was noticed on the inner side of each thigh, which extended nearly the whole length thereof; at 4 P. M. he had a violent chill, and became delirious; he sank rapidly, and died quietly at 7 o'clock on the same evening; and the *autopsy* revealed no cause for his sudden death, excepting the neuropathic gangrene and the consequent septicæmia.

A case of simple fracture of the first lumbar vertebra, with a wood-cut to illustrate it (Fig. 775), was presented on page 757, in which it is not improbable that *septicæmia* arising from a neuropathic eschar was likewise the immediate cause of death; for "the parts in the region of the sacrum were gangrenous," and smelled so badly that it was necessary to apply strong disinfectants (chlorides), in order to suppress the stench.

(2) Neuropathic bed-sores not unfrequently destroy life by inducing *purulent infection*, or *pyæmia*, attended with the production of metastatic abscesses in the viscera. I have already mentioned a considerable number of cases in which this accident occurred, and here is another example:—

J. H. Gray[1] relates the case of a boy, aged 13, who fell thirty-five or forty feet, striking his back, and was stunned. Projection of the sixth or seventh dorsal vertebra was noted; also delirium; paralysis; priapism; incontinence of urine and feces; abnormal heat; excoriation; on ninth day cystitis; bed-sores. He did well for three weeks, but then rigors occurred, and were followed by death twenty-eight days after the accident. *Necroscopy* revealed fracture and displacement forward of the sixth dorsal vertebra; cord crushed, but not compressed; metastatic deposits (abscesses) in several viscera. (Ashhurst.)

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[1] London Hospital Reports, vol. i.

M. Charcot thinks that this sequel of spinal bed-sores is seldom met with. But experience, especially that gathered in old or perhaps infected hospitals, proves the contrary.

(3) Sphacelus of neuropathic origin not unfrequently proves fatal in consequence of the formation of *gangrenous emboli*, or the occurrence of *gangrenous embolism.* "In this variety," says M. Charcot, "thrombi impregnated with gangrenous ichor are transported to a distance, and give rise to gangrenous metastases, which are principally observed in the lungs. This is a point upon which Dr. Ball and myself have insisted in a work published in 1857.[1] But long before us, and even long before the theory of embolism had been Germanized, M. Foville[2] had expressed his opinion that a considerable number of cases of pulmonary gangrene, observed in the insane, and in different diseases of the nervous centres, are caused by 'the transport into the lungs of a part of the fluid which bathes the eschars of the breech.'"[3] I give the preceding quotations from MM. Foville and Charcot, in order to show not only that gangrenous eschars of the sacrum may cause pulmonary gangrene through the agency of pulmonary embolism and pulmonary infarction, but also that French observers have had some share of importance in developing the theory of embolism itself.

(4) Neuropathic eschars prove fatal most frequently of all, perhaps, in consequence of *exhaustion*—that is, the sufferers die worn out by the discharge and irritation, combined with a certain degree of septicæmia which is almost always present in such cases. The process of mortification tends gradually to invade the deeper tissues, as well as to spread more widely on the surface. In this way, the trochanteric synovial bursæ may be laid open, the trochanter itself denuded of periosteum, the gluteal muscles, the nerve-trunks, and the bloodvessels of a certain calibre laid bare. But I can best describe the phenomena of sacral eschars ending in death from exhaustion, by briefly relating an example:—

A female domestic, aged 30, moderately temperate, and of good constitution, was admitted into Bellevue Hospital, on the afternoon of August 30, on account of fracture and luxation of the first lumbar vertebra, with the following history. About 9 or 10 o'clock on the previous evening, while in a somnambulistic state, she walked out of a third-floor window, and, falling two floors, struck upon the slated roof of a shed. She was not rendered insensible, even for a moment, but could give no account of the direction in which the blow was received, excepting that she struck upon her left side. No paralysis nor anæsthesia followed the accident, and no pain except upon motion. The left leg, however, had felt "numb" ever since. No urine nor feces had been passed since the accident.

Upon examination, slight deformity, a slight displacement of a vertebra backward, was detected at the position of the last dorsal or first lumbar vertebra, and very slight tenderness a trifle lower down; but no redness nor ecchymosis, nor any other external mark of injury. The respiration was natural in character and frequency; the pulse rather frequent, but of moderate strength.

The urine was withdrawn by catheter for a few days, and after that was passed involuntarily until death. The bowels acted regularly. In the course of eight or ten days after admission, the vertebral prominence increased so much as to make easy a diagnosis of luxation backward of the first lumbar vertebra. No motor paralysis nor anæsthesia of the limbs or body appeared in the case. The very intense pain occurring upon the slightest attempt at motion, which originally characterized her condition, gradually diminished, and at length in considerable measure disappeared.

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[1] De la coïncidence des gangrènes viscerales et des affections gangréneuses extérieures. L'Union Médicale, 26 et 28 Janvier, 1860.

[2] Dictionnaire de Méd. et de Chirurg. Prat., t. i. p. 556.

[3] Charcot, op. cit., p. 60.

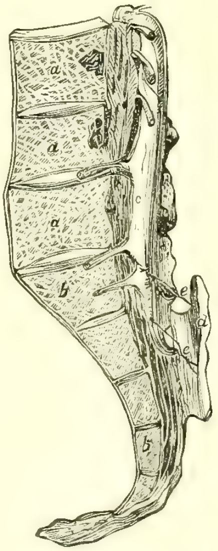
A bed-sore early formed over the sacrum, and slowly proceeded inward or deepened until exposure of the bone was effected. Subsequently, diarrhœa supervened. She sank from exhaustion; and, on October 6, she died, thirty-eight days after the accident.

Autopsy.—Crushing of the body of the first lumbar vertebra, with displacement of the entire vertebra backward, was revealed. Firm union in the fractured vertebra had taken place.[1]

It is worthy of particular mention that a sacral eschar attacked this woman although she had no sensory nor motor paralysis whatever, that the eschar soon followed the accident, that it steadily deepened until it laid bare the sacrum, and that it caused death by producing exhaustion. The sacrum itself was probably necrosed, for it has often been found necrosed in analogous cases.

(5) Finally, sacral eschars of neuropathic origin pretty often prove fatal by destroying the sacro-coccygeal ligament and thus opening the sacral canal, or by penetrating this canal in some other manner; whereupon there quickly supervenes either a *simple, purulent, ascending meningitis*, or a sort of *ichorous, ascending meningitis.* I have already mentioned a number of instances in which the sacral canal was opened by bed-sores with fatal effect. Mr. Hilton states that he has "several times seen fatal mischief result from a bed-sore extending to the interior of the vertebral canal, and causing inflammation of the spinal cord and its membranes."[2] He likewise presents an accurate drawing made from a preparation illustrating this important pathological condition, of which the accompanying wood-cut (Fig. 796) is a copy. This cut will remind surgeons of the close proximity of the spinal dura mater and the posterior wall of the sacral canal to bed-sores. *a, a, a.* A vertical section of the third, fourth, and fifth lumbar vertebræ. *b, b.* A vertical section of the sacrum. *d.* A portion of the sacral arch turned backward. *e, e.* Short, delicate, and elastic ligaments, seen proceeding from the lower part of the spinal dura mater to the sacrum. *c.* Dura mater, containing the cauda equina, spinal pia mater, and spinal arachnoid extending to a point opposite the second bone of the sacrum. Numerous strong ligaments are shown affixing the dura mater to the posterior ligament of the spinal column, opposite the second portion of the sacrum. Three distinct, slender ligaments proceed to the third, fourth, and fifth pieces of the sacrum. (Hilton.) The fact that the spinal membranes extend downward as far as the second piece of the sacrum, is well shown in the cut (Fig. 796). In one of Mr. Hilton's cases death resulted from pyæmia (pyæmic pneumonia), although the bed-sore had reached the interior of the vertebral canal, and involved the membranes of the spinal marrow.[3]

Fig. 796.



To illustrate the penetration of the sacral canal by bed-sores, and the occurrence of fatal spinal meningitis therefrom. (Hilton.)

Of the *ichorous form of ascending meningitis*, MM. Lisfranc and Baillarger have reported many remarkable examples. In this affection, it is found that a puriform, grayish, acrid, and fetid liquid steeps the spinal meninges and the cord itself; sometimes only the lower part, sometimes the whole cord is bathed in this liquid, which, occasionally, is also found at the base of the encephalon, as likewise in the fourth ventricle, in the aqueduct of Sylvius, and even in the lateral ventricles. At all these points in such cases, the cerebral substance is discolored on its surface and to a certain depth, acquiring a slaty-bluish tint, which is a product of imbibition, maceration, and dyeing. (Charcot.) When ichorous cerebral meningitis has a sacral bed-sore for its starting-point, the slaty hue, but more pronounced, is found over the whole extent of the spinal cord, and it grows more strongly marked as one approaches the bed-sore which has opened the sacral canal. Simple, purulent, ascending meningitis, however, is not attended with this peculiar discoloration; but it is unnecessary to dwell longer on this point, although it is by no means an unimportant one.

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[1] New York Journal of Medicine, March, 1859, pp. 244, 245.

[2] Op. cit., pp. 213, 214.

[3] Op. cit., p. 43.

Pathogeny.—From the foregoing exposition of whatever facts are known concerning the variety of sphacelus in question (that is, concerning the acute sacral eschar, etc.), it is evident that the patient's position, or pressure, is never the chief cause of its production, and that in some cases pressure does not assist at all in originating it.

It also appears that its causation in no way depends upon paralysis of sensation and voluntary motion; for, in a case where the first lumbar vertebra was fractured (it is related on page 836), a sacral eschar appeared early and progressed steadily until it produced fatal exhaustion, although there was no paralysis whatever of sensation and voluntary motion. Other examples of similar import have likewise been mentioned in the foregoing pages.

Furthermore, it appears that the acute bed-sore does not arise from vasomotor paralysis (that is, from paralysis of the bloodvessels); for, in the hemiparaplegia which ensues when one lateral half of the spinal cord is divided, the eschar never appears on the side of the sacrum, or in the lower extremity, where the vaso-motor paralysis is to be found, but on the side of the sacrum, or in the lower extremity, where vaso-motor paralysis does not exist. The inference is, of course, conclusive.

Finally, the kind of sphacelus in question does not result from the mere absence of nerve-action; for, in several cases of shot and other fractures of the vertebræ (related above), in which the spinal cord was partially or completely divided, no bed-sores appeared, although the patients survived their injuries several, and, in some instances, many days. The soldier whose vertebral fracture is represented by Fig. 784 (p. 777), survived a complete division of the spinal cord for twenty-nine days, and yet no bed-sore presented itself. Hutin's patient lived fourteen years—although the right half of the cauda equina had been divided by a small-arm missile near its commencement, the left half displaced by it, and its substance much disorganized—and ultimately died of Bright's disease. But examples almost without number can readily be adduced to show that the spinal cord may be divided, either partially or completely, without the supervention of bed-sores, however long the survival be protracted.

On the other hand, in perusing the cases of spinal injury where acute bed-sores, or analogous sphacelations, did appear, and where the condition of the cord revealed by post-mortem examination is described with sufficient minuteness, we generally find it distinctly stated, either that the cord was suffering from active mechanical irritation effected by the displaced and fractured vertebræ, or by the extravasation of blood, or that the cord-substance had undergone certain changes which we know result from the inflammatory process, or that the spinal membranes were inflamed. Thus, in the case of shot-fracture of the spinal column, represented by Fig. 783 (p. 777), in which the missile divided the spinal cord and lodged in the spinal canal opposite the fifth dorsal vertebra, a sacral eschar appeared; two weeks afterwards " sloughing of the lower extremities" was noted; after another month, "sloughing extending" was part of the record made; and six weeks after that, death from exhaustion ensued. At the *autopsy* it was found, not only that the spinal cord was severed, and that the missile lay in the spinal canal, but also that the upper section of the spinal cord was "much softened," that is, exhibited a change which, under the circumstances, was doubtless inflammatory. Most of these particulars are taken from the Medical and Surgical History of the War of the Rebellion, First Surgical Volume, p. 440, where the case is fully reported. Many similar instances have been mentioned in the foregoing pages, where acute sacral eschars or other sphacelations of an analogous character were attended with either an active mechanical irritation or a positive inflammation of the cord-substance, as was proved by post-mortem examination. On the whole, then, the dominant and ever-present fact in such cases is the active irritation of a more or less extensive region of the spinal cord, which mostly shows itself, anatomically, by the changes that characterize inflammation of the cord-substance (myelitis), and, clinically, by the outward phenomena or symptoms that arise from this lesion. Moreover, this conclusion is in strict conformity with the results of experiments on animals, which show that in them the development of gangrenous ulcerations over the sacrum does not supervene on ordinary sections of the cord, but only in cases where inflammation occurs in the cord-substance or membranes around the traumatic lesion. So much concerning the pathogeny of this most troublesome and destructive disorder appears certain.

But it is not probable that all the constituent parts of the spinal cord are equally liable, when excited by irritation or inflammation, to provoke the development of acute bed-sores. The great frequency of this accident in cases of hæmatomyelia, and of acute central myelitis, where the lesion occupies chiefly the central region of the spinal cord, seems to designate the gray substance as playing a predominant part in this respect. (Charcot.) This power is doubtless shared also by the posterior white fasciculi, for M. Charcot has shown that irritation of certain parts of these fasciculi has the effect of determining the production, not only of various cutaneous eruptions, but likewise of dermal necrosis with deep ulceration.[1]

Furthermore, it is perfectly established that traumatism of the cauda equina, and other irritative lesions of the peripheral nerves, may give rise to an acute bed-sore, on the one hand, or to sphacelation of the integuments in their terminal areas, on the other hand. The illustrative examples presented above make this point quite clear; and there are many other examples on record. Perhaps, irritative lesions of the spinal ganglia of the nervi sympathici, too, may sometimes determine the rapid formation of eschars. But on this point we need more light to be thrown by clinical and pathological observations, as well as by experiments on animals.

Finally, in regard to the *essential lesion* of the spinal cord, of the cauda equina, or of the peripheral nerves in general, which determines the development of acute bed-sores and of other analogous sphacelations of the integument, we are still in the dark, at least as far as any positive knowledge of the subject is concerned. But, after all, it may in time yet be demonstrated that there really are *trophic nerves*, as Samuel has supposed, and that the pathological excitation of these nerve-filaments, whether it be effected in the spinal cord, or in the cauda equina, or in the trunks of other peripheral nerves, is attended by the formation of tegumentary eschars in the areas where the disordered nerve-filaments terminate, and over whose nutrition they preside.

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[1] Op. cit., pp. 52, 73, 74.

Prognosis.—Neuropathic bed-sores, and neuropathic sphacelations in general, never bode any good. Still, they portend more of evil when they appear in the course of some affections, than they do when they appear in the course of others. For instance, a sacral eschar very seldom presents itself in a case of injury or disease of the brain which is to have a favorable termination; its appearance in such cases, therefore, constitutes a most inauspicious sign. We might in fact call it *sphacelus ominosus*, the *ominous* bed-sore, by way of distinction. (Charcot.[1]) This accident, I repeat, rarely proves deceptive in cerebral injuries and diseases; and inasmuch as its existence may be discerned from its very incipiency, it becomes of great value, especially in doubtful cases. The only prognostic sign that can at all rival it in cases of sudden hemiplegia, according to M. Charcot, is a very marked fall of the central temperature below the normal, occurring at the outset of an attack. Thus, the vesiculæ and bullæ which are the precursors of neuropathic sphacelus will, from their first appearance on the scene, enable us to form a prognosis with certainty in such instances.

But, in spinal injuries and diseases, recovery may yet take place after neuropathic bed-sores have appeared. Many such examples are on record, and almost every experienced surgeon has witnessed several. There are, however, certain phenomena which portend an unfavorable issue for the neuropathic sphacelations which result from spinal injury. These signs of impending evil are the following: (1) An early appearance of such sphacelations—that is, their occurrence before the pressure resulting from the patient's posture in bed has had sufficient time to share in their causation; (2) Their appearance in parts where pressure has had very little, or even no share at all, in their causation, as, for example, on the ankles, legs, inner surface of the thighs, etc.; (3) Their simultaneous appearance at several different points on both lower extremities; (4) Their very rapid enlargement on the one hand, or their steady enlargement in spite of treatment on the other; (5) The appearance of symptoms denoting that septicæmia, pyæmia, or ascending suppurative meningitis from penetration of the spinal canal, has occurred—a sign which usually denotes that the end is not far off. In a case reported by Mr. Hilton,[2] where a sacral eschar reached the interior of the vertebral canal and involved the membranes of the spinal marrow, pyæmia also supervened, and caused death in nine days. On *autopsy* the whole right lung was found pneumonic, with numerous, well-defined, small collections of pus in different parts of it.

Treatment.—The causal indications should be sought for and fulfilled as far as possible. To this end, in simple fractures and dislocations of the spinal column, reduction should be effected, for thus the risk of mechanical irritation of the spinal cord or its membranes, by the displaced vertebræ, will be more or less considerably lessened. In gunshot and other compound fractures of the spinal column, all foreign bodies should be removed from the wounds. In cases where spinal meningitis or myelitis is present and acting as the efficient cause of the bed-sores or sphacelations (and these cases form a numerous class), potassium iodide, ten grains three times a day, and fluid extract of ergot, one drachm three times a day, should be administered. When ergot has lost its effect, belladonna in rather large doses has sometimes been exhibited with benefit in cases of myelitis. But the chief internal remedies against spinal congestion, spinal meningitis, and spinal myelitis, are potassium iodide and ergot, and both drugs must, as a rule, be given in full or even excessive doses, to secure their good effects in these disorders. I advocate the trial of these remedies in bed-sores and other sphacelations of spinal origin, not only on general principles, but also because, in several instances related in the foregoing pages, the good effects of these remedies were conspicuous in the rapid healing of the ulcers, and in the disappearance of the other spinal symptoms.

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[1] [Charcot uses the term *decubitus ominosus*.]

[2] Op. cit., p. 213.

Although the pressure resulting from the patient's posture in bed is never the chief cause of neuropathic bed-sores, we should always endeavor to prevent its occurrence, or mitigate its effects, by placing the patient upon a water-bed, or by employing the various expedients which were mentioned in Vol. II. (p. 307); but, if possible, a water-bed should be obtained for such cases, because no expedient or combination of expedients will answer the purpose nearly as well. The integuments on the sacrum and nates should be kept dry and clean, that is, unsoiled with decomposing urine and feces; and these parts, in bed-ridden people, should be sponged over at least once a day with diluted alcohol or rectified spirit.

But when the eschar or sphacelus appears notwithstanding these measures, what more is to be done? The indication then is to limit the extent of the slough, as much as possible, by restoring or invigorating the circulation of blood in the affected parts. There are two procedures for fulfilling this indication, both of which possess great value. One of them was devised by M. Brown-Séquard, and I shall proceed to describe it in his own words:—

"I have tried," he says, "to prevent or cure those sloughs which are an evident result of the disturbance of nutrition due to an irritation of the nerves of bloodvessels, by acting upon the bloodvessels of the part where the sloughs exist. I have made experiments upon animals, showing that by applying alternately two poultices, one of pounded ice, the other a very warm bread or linseed poultice, there is a very rapid cure of the sloughs [when] due to a nervous irritation. Several medical men have already obtained the same results in man that I have obtained in animals, by following the plan of treatment that I have proposed. The pounded ice, kept in a bladder, is to be applied for eight or ten minutes, and the warm poultice for an hour or two, or even a longer period. . . . I think I can safely say that, in cases where a slough is beginning, its progress will always be stopped by the means I propose."[1]

The other method is that of galvanism, which was first suggested and employed by Dr. Crussel, of St. Petersburg, and is as follows: A thin silver plate, no thicker than a sheet of paper, is to be cut so as to fit the exact size and shape of the bed-sore. A zinc plate of about the same size is connected with the silver plate by a fine silver or copper wire, six or eight inches in length. The silver plate is then placed in immediate contact with the bed-sore, and the zinc plate on some part of the skin above it—a piece of chamois-leather, soaked in vinegar, intervening, which, however, must be kept moist, or there will be little or no action of the battery. Within a few hours the beneficial effect becomes perceptible; and, in a day or two, the cure is in most cases complete. In a few instances a longer time is required. "I have frequently seen," Professor Wm. A. Hammond says,[2] "bed-sores three or four inches in diameter, and half an inch deep, heal entirely over in forty-eight hours." Mr. Spencer Wells states that he has often witnessed large ulcers covered by granulations within twenty-four hours, and completely filled up and cicatrization begun in forty-eight hours, under this treatment; and that it is the best of all methods for treating ulcers of indolent character, and bed-sores. Professor Hammond further states: "During the last twelve years I have employed it to a great extent in the treatment of bed-sores caused by disease of the spinal cord, and with scarcely a failure—indeed, I may say without any failure except in two cases where deep sinuses had formed which could not be reached by the apparatus."[1] If this plan of treatment should prove equally successful in other hands, a large share of the mortality which arises from spinal injuries may be avoided.

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[1] Lectures on the Physiology and Pathology of the Central Nervous System, etc., pp. 260, 261.

[2] Diseases of the Nervous System, 1881, p. 453.

In the absence of ice, M. Brown-Séquard's method may be employed by alternately applying to the bed-sores sponges, one of which is saturated with hot water and the other with cold water. This should be done several times every day, for five or ten minutes at a time; the effect is to increase the vascular activity of the part, and to promote granulation.

Disorders of the Urinary Organs arising from Lesions of the Spinal Cord.

Disorders of the urinary bladder, the ureters, and the kidneys, result from lesions of the spinal cord—from the so-called idiopathic, as well as from the traumatic affections of that organ—with even greater frequence than the bed-sores and other neuropathic sphacelations which have just been described; for, while the tegumentary eschars that arise from spinal lesions are always attended by more or less important disorders of the urinary organs, the latter not unfrequently present themselves in cases where the spinal cord is injured or diseased, without the fellowship of the former. Moreover, these urinary affections very often aid materially in producing death, and, not unfrequently, are the chief or even the sole proximate cause of a fatal issue, in such cases. These disorders, therefore, possess a degree of importance which is scarcely inferior to that of the neuropathic lesions of the integuments which have just been discussed; and they likewise should be attentively considered in this place.

The urinary affections that result from lesions of the spinal marrow are quite diversified, but may all be embraced and arranged under the following heads: (1) Paralysis of the bladder; (2) Alterations of the urinary secretion; (3) Inflammation of the kidneys, of the ureters, and of the bladder.

Paralysis of the Bladder.—Inasmuch as the muscular apparatus belonging to the urinary bladder consists of two distinct parts, namely, (1) that which is employed to retain the urine in the organ, consisting of the *sphincter vesicæ* muscle, and (2) that which is used to expel the urinary secretion from the organ, consisting of the *detrusor urinæ* muscle; and, inasmuch as each of these muscles has a distinct reflex motor centre in the spinal cord, upon which its action or inaction depends, there are two distinct forms of vesical paralysis, one of which is manifested by *retention*, and the other by *incontinence* of urine.

The reflex motor centre of the detrusor urinæ, according to Dr. Bramwell,[2] is situated in the segments of the spinal cord which correspond to the 3d, 4th, and 5th sacral nerves, and the normally contracted state of the sphincter vesicæ is due to the action of a tonic centre which is situated in the segments of the cord corresponding to the 2d, 3d, and 4th sacral nerves. The reflex motor centres of these muscles are not only quite distinct in the anatomical sense, but they are likewise completely antagonistic in their motor action. The mechanism of normal micturition, then, appears to be as follows: 1. When the bladder becomes full enough, the sensory nerve-filaments in its mucous membrane are stimulated, and an impression is conveyed along the sensory nerves to the reflex centres for the detrusor and sphincter muscles in the spinal cord, and to the sensorium. 2. As a result of the sensory impression conveyed to the brain, the desire to urinate is experienced. 3. As a result of the impulse carried to the reflex motor centres in the spinal cord, the action of the detrusor centre is excited, while the action of the sphincter centre is inhibited. If the circumstances for urination be favorable, an impulse is sent from the brain by the will to the tonic centre for the sphincter, inhibiting its action, and causing the sphincter muscle to relax; also to the centre for the detrusor urinæ, strengthening the excitation of that muscle to contract, which has already been aroused by the reflex impulse from the bladder. In health, all these processes are simultaneously accomplished, and the result is micturition. When, however, the circumstances are not convenient for performing the act, it can be delayed or prevented (*a*) by voluntarily inhibiting the motor centre for the detrusor urinæ; (*b*) by causing the urethral muscles at the neck of the bladder to contract, likewise by an effort of the will; and, (*c*) possibly, by strengthening the tonic centre for the sphincter vesicæ, in the same manner, and at the same time. (Bramwell.) Thus it will be perceived that three distinct sets of nerves are always concerned in the act of voluntary micturition, namely, (1) a set by which the detrusor urinæ muscle is automatically operated; (2) a set by which the sphincter vesicæ is also operated automatically; and (3) the conducting fibres of the spinal cord through which the sentient being is enabled to perceive the need of micturating, and to send the mandate of the will down to micturate at once or to postpone the act, as circumstances may determine. Moreover, these physiological data can all be usefully employed in diagnosticating the injuries and diseases of the spinal cord and spinal column.

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[1] Ibid., p. 453.

[2] Diseases of the Spinal Cord, pp. 117–119. New York. 1882.

There are two forms of *retention of urine* which arise from lesions of the spinal cord. In one of them, the conducting paths in the cord alone are at fault, for the reflex motor centres which determine the action of the vesical muscles are not affected. In such a case, the patient cannot micturate voluntarily, because the mandates of the will are not conveyed by the conducting fibres of the cord down to the motor centres for the vesical muscles. In such a case, too, the bladder will continue to empty itself automatically from time to time; that is, as soon as the quantity of urine collected in the viscus becomes sufficient to excite reflex contraction of the detrusor urinæ muscle, with inhibition of the sphincter muscle's tonic centre, evacuation of the viscus ensues. Examples of this form of urinary retention are not unfrequently afforded by lesions of the spinal cord occurring in the cervical or dorsal regions, when the nerve-injury is restricted to the site of the lesions themselves, and when, consequently, the reflex motor centres for the vesical muscles are unaffected. In such cases, the act of urination usually occurs without the patient's knowledge, as well as without his consent. In the other form of urinary retention, the difficulty arises from the fact that the reflex motor centre for the detrusor urinæ has ceased to act, while the tonic centre for the sphincter still continues to work, that is, from the fact that the detrusor muscle is paralyzed while the sphincter is not paralyzed. In examples of the first-mentioned form of urinary retention, catheterization may be unnecessary, and it is perhaps from his experience with this class of cases that Mr. Hutchinson[1] has been led to think that catheterization is unnecessary in all cases of spinal injury above the loins, unless vesical hyperæsthesia be also present. In the other form of urinary retention, however, that in which the detrusor muscle is paralyzed while the sphincter continues in a state of tonic contraction, catheterization performed at suitable intervals is always necessary, and must never be neglected; in fact, the operation is indispensable in such cases, for, if it be not performed, the urinary secretion will continue to accumulate in the viscus, until it becomes distended even to the point of bursting. I have myself seen more than one case, in civil as well as in military practice, of vesical paralysis arising from spinal injury, in which, from want of catheterization, the bladder became so much distended as to cause a notable tumefaction, discernible on external examination, and in which, on introducing a flexible instrument, a great quantity of urine, an ordinary chamber utensil more than half full, or considerably more than half a gallon, was withdrawn, and that, too, when there were no signs of urinary overflow present. Inasmuch as these two forms of urinary retention are clinically distinguishable from each other only by experimentally ascertaining whether reflex motor action can be excited in the detrusor muscle, the safest course for the surgeon to pursue, in both forms, is to draw off the water at suitable intervals with a perfectly clean, flexible instrument.

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[1] London Hospital Reports, vol. iii. 1866.

Incontinence of urine, when it results directly from injury or disease of the spinal cord, is always due to paralysis of the sphincter muscle, that is, to functional inactivity or destruction of the tonic centre in the cord upon which the contraction of its fibres, and the closure of the urethral orifice of the bladder, entirely depend. Paralysis of the sphincter vesicæ arising from destruction of its reflex centre, is almost invariably associated with paralysis of the detrusor urinæ, because its reflex centre is also destroyed. These reflex centres may be directly destroyed by injuries, *e. g.*, by fractures or dislocations of the lumbar vertebræ, or by hemorrhage into or inflammation of the cord-substance. But, as already intimated, paralysis of the sphincter vesicæ is very rare *per se.* It is nearly always accompanied by paralysis of the detrusor muscle, and by paralysis of the rectum.

Interruptions of the conducting parts to and from the brain, in the spinal cord above the reflex centres for the vesical muscles, are of frequent occurrence in spinal injuries. When the lesion of the cord is suddenly produced, it may be accompanied by a concussion of the cord which temporarily arrests the reflex motor functions of all the segments situated below the lesion, including of course the urinary centres. In chronic cases, the effect of the rachidian lesion varies with its position and extent. When the sensory conductors or sensory perceptive centres only are affected, the desire to urinate is not perceived; the reflex arc is uninjured, and, as soon as the bladder becomes sufficiently distended with urine, it is unconsciously evacuated. It, therefore, should be remembered that the involuntary discharge of urine and feces, in cases of paraplegia or coma, does not necessarily imply any paralysis of the bladder or rectum.

When the motor and inhibitory conducting fibres of the cord alone are interrupted, the desire to urinate is perceived, but the act itself takes place quite independently of volition. It can neither be assisted nor deferred by any effort of the will in such cases.

Concussion of the spinal cord, especially when the lower part of it alone is affected, may be attended by paralysis of the detrusor muscle, indicated by retention of urine, when no other portion of the muscular system appears to be paralyzed.

Concussion of the spinal cord, when severe enough to produce paraplegia (that is, both voluntary-motor and sensory paralysis in the lower part of the body), may also suppress for a time the reflex motor functions of the urinary centres, as well as the conducting functions of the rachidian fibres; and then paralysis of the sphincter muscle, with incontinence of urine, will also be present.

Congestion of the spinal cord coming on some days, it may be, after falls or blows upon the lower part of the spinal column, sometimes causes paralysis of the detrusor muscle, with retention of urine, when no such paralysis followed the injury.

Myelitis causes incontinence of urine because it destroys the tonic centre for the sphincter vesicæ, and thus paralyzes that muscle, as well as the sphincter ani, etc.

Alterations of the urinary secretion very often arise from injuries and diseases of the spinal cord. Briefly stated, these alterations consist of alkalinity, which is often excessive; of the presence of an abnormally great quantity of the phosphates; and of the existence, in the urine, of blood, pus, and mucus. Occasionally the urinary secretion is entirely suppressed in such instances.

It has long been noticed by surgeons that, after fractures of the vertebral column with consecutive lesions of the spinal cord, the composition of the urine very frequently and very rapidly becomes altered. In almost all cases of traumatic myelitis, it soon presents a remarkable alkalinity. I have also reported two cases of spinal injury with marked displacement between the fifth and seventh cervical vertebræ, and paraplegia, in which it was observed on the second day after the accident that the urine when withdrawn by catheterization had a strongly ammoniacal odor, that is, was strongly alkaline, although that operation had been thoroughly performed as often as needful ever since the accidents. A great many cases have likewise been mentioned in the foregoing pages, in which, soon after the reception of spinal injuries, the urinary secretion was found to be alkaline instead of acid. Sir B. C. Brodie[1] especially called attention to the characteristics presented by the urine in the case of persons stricken with traumatic paraplegia. He observed the urine to be alkaline, and to exhale a fetid, ammoniacal odor at the moment of emission, on the second, on the third, and on the eighth day. Soon afterward, this secretion contained blood-clots, muco-purulent matter, and deposits of ammoniaco-magnesian phosphates. It would be easy to collect from authors of repute a very great number of analogous cases. I shall mention but two additional observations.

Dupuytren pointed out that, in cases of spinal fracture with lesion of the cord, the catheter when allowed to remain in order to guard against retention quickly became coated with a calcareous incrustation.

Mr. Shaw[2] relates the case of a young man who had fracture of a dorsal vertebra and complete paraplegia, caused by falling from a tree. Extensive sloughs formed on the nates, but they healed, and he appeared to be recovering with paralysis, after surviving eight months. During most of this time his water flowed continuously into a urinal, and the catheter was not used. Eventually, however, his urine became turbid and fetid; and he died with symptoms of aggravated disease of the bladder. The *autopsy* revealed a discolored and shreddy state of the vesical mucous membrane, with five phosphatic calculi as large as pigeons' eggs, and coated with mucus, in the bladder; also phosphatic calculi were found impacted in the calices, and lying loose in the pelvis, of each kidney.

The alkaline and phosphatic characters of the urine are met with in lesions of the spinal cord so constantly, that their presence must be mainly due to the operation of some single cause which acts efficiently in nearly all the cases. Some hold that this condition of the urine is caused principally by the introduction of septic matters from without into the bladder. But this explanation utterly fails to account for a numerous class of cases in which no catheters excepting those perfectly free from septic matters are employed, or in which the urine is found to be ammoniacal and phosphatic on the very first occasion that the catheter is introduced, or in which catheterization is not employed at all from first to last, and still the urine is ammoniacal and phosphatic. Moreover, the use of catheters, and bougies, and sounds is a common thing in the practice of surgery, and yet no such effects appear in any other class of cases. I have no doubt that these effects mainly arise from neurotrophic or neuropathic disturbance of the kidneys and bladder, as was originally pointed out by M. Brown-Séquard. The sanguinolent or muco-purulent qualities of the urine, in such cases, result directly from congestion or inflammation of the kidneys and bladder. I have also seen some cases belonging to this category in which the quantity of the urinary secretion was much increased above the normal.

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[1] Medico-Chirurgical Transactions, 1836, p. 148.

[2] Holmes's System of Surgery, vol. ii. p. 401, 2d ed.

Finally, excess of phosphates occurs in many cases of cord-disease, independently of bladder-paralysis (as is generally known and admitted); I, therefore, claim that the neutral or alkaline condition of the urinary secretion, with its remarkable proneness to speedily decompose, which is often witnessed in the same, as well as in analogous cases, also occurs independently of bladder-paralysis, and, like the former, results from the rachidian lesion, in consequence of the disturbance it effects in the working of the kidneys. In this way alone can be satisfactorily explained the strongly ammoniacal odor perceived at the moment of emission, in urine that contains neither mucus nor pus, which I have observed in at least one instance of traumatic paraplegia arising from displacement of the lower cervical vertebræ, in less than thirty hours after the accident, when the subject (a man) was previously in perfect health, and when it was not possible for the kidneys or bladder to have sustained any direct injury. The urinary secretion became abnormal in this case, in consequence of the morbid excitation of the spinal cord which was produced by the injury.

INFLAMMATION OF THE URINARY ORGANS.—As we have seen that important alterations of the urinary secretion very often result from injuries and diseases of the spinal cord, and as we have found that acute bed-sores and other neuropathic sphacelations of the integuments not unfrequently arise from the same causes, so also we shall find that inflammation of the kidneys, and of the ureters, and of the bladder, or rather of the mucous membrane which lines these organs, often has an identical origin.

This form of renal and vesical inflammation is a very important disorder, because (1) it gives much trouble to patients and their attendants, and (2) it very often proves fatal; for, as Mr. Bryant justly remarks, when death occurs as a result of injury to the dorsal region of the spine, suppuration of the kidneys, cystitis, and bed-sores, are the most common proximate causes thereof.[1]

M. Brown-Séquard first called attention to the neuropathic origin of this highly destructive form of renal and vesical inflammation. In 1858, he said :—

> "Another morbid change due to a mechanical excitation of the spinal cord may cause death after a fracture of the spine ; it is the alteration which takes place in the kidneys [and bladder], an alteration sometimes amounting to a real inflammation. We hardly need to say that the changes in the urinary secretion, owing or not to an inflammation of the kidneys, also the hæmaturia, and the alterations in the mucous membrane of the bladder, in cases of fracture of the spine, are morbid phenomena depending upon

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[1] Op. cit., p. 202.

an irritation of the spinal cord, and not upon a paralysis due to a division of the cord. For on the one hand, a [mere] section of the cord is never followed by these alterations in the kidneys or the bladder; and, on the other hand, we often observe these alterations too quickly after the spine has been fractured, to admit that they are due to a paralysis."[1]

In the same lecture he also said:—

"The influence of a mechanical excitation of the spinal cord by a piece of broken bone [or of a pathological excitation of the cord by an inflammatory process], deserves the full attention of the physiologist and the practitioner. Among the alterations of nutrition, . . . in cases of that kind, we will particularly notice the sloughs on the sacrum, and the various morbid changes that take place in the bladder and in the urinary secretion. These alterations in nutrition and secretion are certainly frequent causes of death after fractures of the spine. Therefore, it is of the greatest importance to find out the mode of production of these morbid changes, and to try to prevent or to cure them."[2]

The mode of *causation*, as well as the *phenomena* of the renal and vesical inflammations which result from lesions of the spinal cord, can be most briefly, as well as clearly set forth, by presenting a few examples; and a very instructive one has already been mentioned on page 749:—

A young infantry soldier, aged 19, fractured his fifth cervical vertebra, without displacement, while bathing in the Arkansas River, by diving headforemost into shallow water, and immediately became paraplegic from concussion of the spinal cord. Intrathecal extravasation of blood ensued, and, on the following day, the cord showed signs of compression arising from this cause. But absorption of the extravasated blood occurred, the symptoms of paraplegia gradually passed away, and in eight days he became able to pass his urine without a catheter. He continued to improve during the next four or five days, until traumatic spinal meningitis rather suddenly supervened, its invasion being marked by chills and by a rise in the body-heat. Myelitis followed. In two or three days alterations in the urinary secretions began to appear. I will now quote the words of the official report: "On the morning of the 18th, the urine became turbid." "By the morning of the 20th, the pulse had become so frequent that it could not be counted, the bowels were loose, the urine was ammoniacal and thick with mucus." "A very high temperature (105°) followed. The patient at this time was still able to pass his urine without a catheter; but [hæmaturia supervened and], on the 21st, this instrument was used with difficulty, owing to the formation of clots in the bladder. The patient also suffered from decubitus [bed-sores], and, by the 24th, his stomach became so irritable as to retain scarcely anything. On the day following his appetite was entirely gone. On the 26th the temperature was 91.8°. He died at noon on the 28th," twenty-five days after the accident, and ten or twelve days after his urine first began to be abnormal. The *autopsy* revealed the following urinary lesions: "The kidneys were enlarged and gorged with blood; the pelvis of the left being filled with pus." "The ureters were very dark, and one of them contained a clot at the entrance of the bladder. The walls of the bladder were of a dark-purple color, inflamed, and thickened; the mucous membrane being absent in patches."[3]

The urinary lesions in this case did not arise from injury (traumatism) of the kidneys or bladder, for the urinary discharge did not present any morbid appearances until a fortnight after the accident; they were not due to paralysis of the bladder, for the urinary paralysis had disappeared, and the man had passed his water at will for a week before it presented any abnormal change; they were not caused by the introduction of septic matters from without, because catheterization had been discontinued for a week before "the urine became turbid," and was not again resorted to until three days afterward, when hæmaturia had occurred, and the urethral outlet of the bladder had become choked with coagula. There remains, then, no appreciable or perceptible cause whatever for the remarkably inflamed state of the kidneys, ureters, and bladder, which the autopsy revealed in this case, excepting the excitation of the spinal cord by the secondary meningitis and myelitis, which had supervened two or three days before the urinary secretion "became turbid." Thus, it is shown that the urinary lesions in this case had a neuropathic source. Moreover, an acute bed-sore—that is, a neuropathic eschar—presented itself, at the same time, over the sacrum, in this patient; this circumstance also affords presumptive evidence that the urinary lesions had a similar origin.

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[1] Op. cit., p. 249.

[2] Ibid., p. 248.

[3] Circular No. 3, S. G. O., August 17, 1871, pp. 129–131.

The urinary lesions appear to have been the chief proximate cause of this patient's death, which occurred about ten days after the signs of these lesions first became visible. This neuropathic nephritis and cystitis, etc., therefore, ran a remarkably rapid course, and quickly proved fatal. The symptoms presented themselves in the following order: On the first day, it was observed that the urinary discharge was "turbid;" no doubt it was also ammoniacal. Two days afterward, it was remarked that the urinary discharge was highly "ammoniacal and thick with mucus," that the "bowels were loose," and that great prostration with "a very high temperature (105°)" was also present. After still another day, hæmaturia supervened, and the urethral outlet of the bladder becoming plugged with clotted blood, it was necessary to introduce a catheter. On the same day it was noted in the clinical history that the patient was also suffering from bed-sores. In three days more there was extreme anorexia, with very great gastric irritability; and in four days after that death ensued. This *peracute* inflammation of the urinary organs wrought the following structural changes: The kidneys were intensely hyperæmic, and therefore enlarged, while the pelvis of the left one was filled with purulent matter. The coats of the bladder were intensely inflamed, dark-purple in color, and thickened; its mucous membrane had also sloughed off in patches. The ureters, likewise, were very dark in color and intensely inflamed. In consequence of these structural changes, the urinary secretion speedily became loaded with muco-purulent matter and blood. The hæmaturia which occurred during life was obviously caused by the rupture of the over-distended blood-vessels of the kidneys, etc. No wonder, then, that general prostration of an extreme character should rapidly come on in such a case of renal and cystic inflammation, and that death should speedily ensue.

Another highly instructive example of neuropathic inflammation of the kidneys, ureters, and bladder, has likewise been mentioned in these pages already (p. 820); but it is well worth further study, and I shall therefore speak of it again. It was originally recorded by Sir W. Gull:—

A man, aged 25, contracted acute myelitis of the dorsal region in consequence of straining his back in lifting a heavy weight. No bones nor ligaments, however, were injured. On the morning of the second day after the accident he found himself paraplegic on walking, in consequence of the rachidian inflammation. On the fourth day after the injury he was admitted into Guy's Hospital. There was already complete paraplegia, together with a sacral eschar; and ammoniacal urine constantly dribbled from his paralyzed bladder. Forty-one days after the accident, or thirty-seven days after entering the hospital, he died. At the *autopsy*, commencing suppuration in the cortical substance of the kidneys was noted. The mucous membrane of their pelves was greenish in color, with patches of greenish-colored fibrinous exudation thereon. The mucous membrane of the ureters and bladder was in the same condition. The bladder contained a quantity of muco-purulent fluid. The substance of the spinal cord was changed into a thick, greenish, muco-puriform liquid throughout its entire thickness, opposite the fifth and sixth dorsal vertebræ, while the cervical and lumbar portions of the cord were unchanged.

Is there any room for doubt in regard to the etiology of the renal and vesical inflammation which the autopsy revealed in this case? Can the origin of this inflammation be assigned with propriety to any cause, excepting the extremely well-marked myelitis, and the morbid excitation of the spinal cord which it occasioned? It cannot be ascribed to the introduction of septic matters from without, because there is no evidence nor probability that a catheter was ever used in this case; and it does not appear that any necessity ever existed for using a catheter on this man, inasmuch as his urine is known to have been discharged by dribbling (from paralysis of the sphincter vesicæ) almost from the outset, and probably was discharged in this manner from the very outset of the case. Moreover, an acute bed-sore of large size presented itself in the sacro-gluteal region, and this, together with the urinary lesions, destroyed the man's life; and, as the sacral eschar had a neuropathic origin, even so the urinary lesions had the same origin.

Although the inflammatory process in the urinary organs was much less acute in this than it was in the preceding example, the textural changes produced by it, and revealed by the autopsy, were quite well marked. They were as follows: Suppuration in the cortical portion of the kidneys; inflammatory discoloration, and, no doubt, thickening of the mucous membrane lining the renal pelves, the ureters, and the bladder; also greenish-colored fibrinous exudation collected in patches on every part of this membrane. The greenish hue of the exudation, as well as of the inflamed mucous membrane itself, was due to staining with the red corpuscles of the blood; hæmaturia had doubtless supervened some time before death. Finally, the urinary bladder contained a quantity of muco-purulent liquid, the muco-purulent elements of which had been produced by the inflammatory process.

Many other examples belonging to the same category have been presented in the foregoing pages. Should, however, additional evidence be required in regard to the etiology of the urinary disorders under consideration, it may readily be found in M. Charcot's Lectures, already so often quoted: evidence which, although weighty and convincing, cannot be reproduced here for want of room.

To briefly summarize the *symptoms* which usually attend the neuropathic inflammations of the urinary organs that very frequently supervene in cases of spinal injury: Soon after the accident, that is, within a period beginning on the second, and ending about the ninth day thereafter, it is observed that the urine, previously acid and clear, or perfectly normal, suddenly becomes alkaline, and exhales a pungent ammoniacal smell at the moment of emission. Shortly afterward, it is noticed that the urinary discharge has a cloudy and turbid look, arising from the admixture of mucus, as well as a strongly ammoniacal odor. The quantity of this mucus gradually increases until the urinary discharge becomes ropy, tenacious, and so thick from this cause that it even adheres to the bottom of the vessel. In a short time, a white substance—the phosphate of lime—is found mixed with the mucus. Pus-corpuscles and blood-disks also present themselves. The quantity of the former may be so great as to cause a muco-purulent appearance. Oftentimes, the blood-disks present themselves in such large number as to constitute a veritable hemorrhage from the urinary organs, technically denominated hæmaturia. But blood-disks will often be seen with a microscope, when to the unaided eye the urinary discharge does not present a sanguinolent appearance. In the chronic cases, and near the end of most of the fatal cases, the urinary discharge consists apparently of a muco-purulent liquid, in which, however, blood-corpuscles or their remains are almost always found by microscopical examination, intermingled with pus-cells and renal and vesical epithelium, that is, muco-pus, with vibriones and phosphates, etc.

To epitomize the *anatomical lesions* which usually accompany the neuropathic inflammations of the urinary organs that occur in cases of spinal injury: They are hyperæmia, more or less intense, according to the case, with tumefaction and dark-red or purple discoloration of the mucous membrane lining the kidneys, the ureters, and the bladder; intense hyperæmia with tumefaction of the renal parenchyma, and of the walls of the ureters and bladder; fibrinous exudation in patches on the mucous membrane lining these organs; extravasated blood in both a fluid and coagulated state in the pelves of the kidneys, the canals of the ureters, and the cavity of the bladder; suppuration of the secreting portions of the kidneys, and abscess of their pelves; inflammatory thickening of the coats of the bladder and ureters, with softening and erosions of their lining or mucous membrane. In such cases, patches of the mucous membrane are apt to be cast off as sloughs, and the inflammatory process, being violent, generally involves also or extends to the other tunics of the bladder and ureters, as well as to the parenchyma of the kidneys: As a rule, the inflammatory process in such cases does not appear to start in the bladder and spread thence into the kidneys, nor *vice versa;* but it is simultaneously kindled in all parts of the mucous membrane belonging to the kidneys, ureters, and bladder. In chronic cases, phosphatic calculi form in the kidneys, as well as in the bladder, and in either place they may set up fatal irritation.

Thus, it will be perceived that the inflammatory process which is set up in the mucous membrane of the urinary organs by certain morbid excitations of the spinal cord, bears, at least "in the acute" instances, no inconsiderable resemblance to the necrotic processes which are set up in the integuments by the operation of the same causes. The destructive process in both is characterized by intense, dark-colored hyperæmia, extravasation of blood from ruptured capillaries, and sloughing of the tissues involved. In the less severe or chronic cases, the urinary mucous membrane exhibits pathological changes quite analogous to the cutaneous erythema and other diffuse phlogoses of the integuments which are caused by similar lesions of the spinal cord, that have been described above.

Furthermore, it is highly probable that when the urinary secretion comes into contact with the inflamed mucous membrane of the bladder, ureters, etc., it suffers decomposition in consequence of such contact, just as happens in ordinary cystitis; by which decomposition it acquires highly irritating properties that in turn may react upon the already inflamed mucous membrane, and augment its disorder. The urine rots while lying in the bladder, in such cases, not because the walls of the bladder may chance to be paralyzed at the time, as Mr. Shaw and others have vainly asserted, but because it there becomes tainted with the products of the inflammatory process which is going on in the bladder, the ureters, and the kidneys. This statement is fully borne out by what occurred in the *peracute* example just now related—the example in which a young soldier had sustained fracture without displacement of the fifth cervical vertebra in consequence of diving headforemost into shallow water: on the fifteenth day after the accident, there supervened a neuropathic inflammation of his kidneys, ureters, and bladder, which caused death in ten days, although he had been able to pass his water at will for a week previously (which proves that the bladder-paralysis had been absent for a week), and although it was not necessary to use a catheter on him again until three days after the urinary disorder had appeared, and then the instrument was introduced, not because the bladder was paralyzed, but because its urethral orifice was choked with blood-clot arising from hæmaturia. Moreover, to say that in such a case the rotting urine produced an inflammation of the bladder which subsequently spread to the kidneys, would be to blindly put the effect in the place of the cause, and perhaps lead to erroneous practice.

Treatment.—From the foregoing account of the urinary lesions that result from certain morbid excitations of the spinal cord, it is obvious that any plan of treatment which does not fulfil the causal indications—which does not put to rest the agencies that create these sad lesions—cannot do much good in such cases. I have thus patiently and thoroughly inquired into the etiology of these disorders with no purpose to dig up and exhibit any pathological curiosities; but, rather, in doing this I have been moved by a strong desire to devise, if possible, some plan of treatment which shall prevent and perhaps even cure these deplorable lesions. And, inasmuch as they generally arise from congestion or inflammation of the spinal cord, or of its membranes, or are greatly augmented by these affections of the central nervous system, the first indication to be fulfilled in treating the neuropathic lesions of the urinary organs, is to subdue the central nervous affections upon which their existence depends. To this end I recommend the administration *per orem* of fluid extract of ergot, of potassium iodide, and of belladonna, in the doses and in the manner already laid down in describing the treatment of neuropathic bed-sores (page 840), which it is not necessary to repeat in this place. All other means of fulfilling the causal indications which are there mentioned should be employed in these cases also; and less inconvenience will be experienced in carrying out this treatment from the fact that when these neuropathic disorders of the urinary organs make their appearance, neuropathic bed-sores almost always present themselves at the same time. In regard to the results of this plan of treatment, I find, on a reperusal of some cases in which it was advantageously employed for bed-sores, that it proved equally useful for the accompanying urinary lesions. Belladonna plasters, applied over the kidneys, may do good in all such cases.

The urine, as a rule, being strongly ammoniacal and therefore very pungent, should not be allowed to stand in the inflamed bladder, and in the case of any paralytics who cannot void it at will, or from whom it does not flow spontaneously, it should be withdrawn by catheterization as often at least as every four or six hours; but, at the same time, every precaution must be taken, by using only a perfectly clean instrument, etc., to prevent entirely the introduction of septic matter into the bladder.

Hæmaturia often occurs in consequence of neuropathic inflammation of the kidneys, ureters, and bladder. When it proves dangerous or troublesome, it should be treated on the plan already prescribed for traumatic hæmaturia (page 704 *supra*), which it is unnecessary here to repeat. It will, however, be necessary to break down and wash out the coagula by injecting warm water medicated with boracic acid through a large-sized catheter, more frequently in these than in the traumatic cases.

The sloughs falling from the inflamed mucous membrane, with the mucopurulent and phosphatic, or mortar-like matter that may collect in the bladder in such cases, should likewise be washed out by injecting warm water impregnated with boracic acid through a double catheter.

TYMPANITES ARISING FROM LESIONS OF THE SPINAL CORD.

All lesions of the spinal column or spinal cord that cause paraplegia, may be attended by distension of the abdomen with gaseous substances which are generated and held in the abdominal portion of the alimentary canal, that is, in the stomach, and in the small, as well as in the large intestines; their most common seat, however, being the arch and sigmoid flexure of the colon. In such cases, the distended belly is tense and elastic; and, on percussion, it sounds like a huge bladder or a drum filled with air. This kind of abdominal tumefaction has with much propriety been called *tympanites*, because, when struck, it sounds like a drum. The intestinal gases accumulate within the digestive tube in such cases, because the muscular wall of the abdomen and the muscular coat of the intestines, being paralyzed in consequence of the spinal lesion, are no longer able to contract and thus expel them; and since, through loss of contractility, the abdominal and intestinal muscles can offer no effective resistance to the accumulation of these gases, it often goes on until the abdominal distension becomes enormous. The tympanites in such cases is symptomatic of the spinal lesion; and, when enormous or even very considerable in degree, it is usually a fatal sign.

But tympanites always tends in such cases to embarrass the patient's breathing by opposing the descent of the diaphragm during the inspiratory movement; and, when it is very considerable, it causes corresponding dyspnœa. It is, however, in those cases of spinal injury where the paraplegia extends up to the root of the neck—those cases wherein the respiratory movements are performed by the diaphragm alone, and where consequently the respiration is said to be diaphragmatic or abdominal—it is in such cases that tympanites does the most harm, and often aids with no inconsiderable force in shortening life, by increasing the difficulty of breathing, which perhaps is already very great. Many cases have been mentioned or referred to above, in which this very thing occurred. But probably the most notable example was presented on page 816. The case was that of a cavalry soldier, who in a brawl received a shot-wound of the neck, which fractured the spinous process of the last cervical and the laminæ of the first dorsal vertebra, opened the spinal canal, ruptured the theca vertebralis, and drove several small fragments of bone into the substance of the spinal cord. In this case, "the paralysis of the abdominal and intestinal muscles allowed an accumulation of gases to take place within the intestines, to such an extent as greatly to augment the already existing difficulty of respiration. It was found expedient to introduce an elastic tube, from time to time, through which the gases found vent, when pressure was made, externally, on the abdomen."[1] Tympanites, therefore, not unfrequently constitutes in cases of spinal injury a complication which urgently demands the surgeon's attention.

Treatment.—The kind of tympanites in question is always symptomatic of some affection of the spinal cord which, as a rule, interrupts its reflex-motor, as well as its conducting functions. The nature of this central nervous affection should be ascertained, and, if possible, the disease itself should be removed; which can often be done, if it consist in concussion, congestion, or one of the less severe types of inflammation of the spinal cord or its membranes, by carrying out the corresponding plans of treatment which have already been laid down in these pages.

When immediate relief from the tympanitic distension is urgently demanded, it has been proposed by some surgeons to resort to the operation of *paracentesis*, performed on the descending colon with a long narrow trocar and canula; but, inasmuch as this operation is never, in my opinion, justifiable, I shall not take space to describe the steps that pertain to it. The best way to let the wind out in such cases is by introducing a flexible tube of suitable size and length, through the anus and rectum into the sigmoid flexure of the colon, as was originally done, I believe, with success in analogous cases, by Dr. O'Beirne, who used an œsophagus tube for the purpose—a method which likewise was successfully employed in the case just related.

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[1] Circular No. 3, S. G. O., August 17, 1871, pp. 21, 22.

Should it be necessary to discharge the wind from the stomach, or from the small intestines, by an operation, it might be done with comparative safety by aspiration.

Antispasmodics and carminatives, æther, ol. anisi, assafœtida, tinct. cardamomi, tinct. zingiberi, tinct. rhei, or ol. terebinthinæ, will of course be administered, by the mouth or by the rectum, in these cases; and warm purgative medicines, and warm purgative clysters, should likewise be employed.

PRIAPISM IN CONSEQUENCE OF SPINAL INJURIES.

The term priapism is here used to signify a more or less complete erection of the penis (but most often it is incomplete), which is unattended by voluptuous sensations, and which is caused by injury or disease of the spinal cord, instead of by sexual desire or normal excitation.

This condition of the penis is very often observed in cases of spinal injury. It will therefore be instructive, as well as interesting, to consider briefly the clinical relations, the etiology, and the import or signification of this disorder of the male sexual organs.

Phenomena of Priapism.—Priapism is usually described as a mere "turgescence," or bare "stiffness" of the penis, which does not amount to an erection in the true sense of the term. For it is commonly observed in priapism, that while the "turgescence," or "stiffness," does not attain the rigidity of a true erection, it likewise does not cause the head of the penis to rise upward beyond a line drawn perpendicularly to the long axis of the body. Moreover, the penis does not of necessity become increased in length and breadth, or diameter, in priapism, as it does in normal erection, or in that state of the organ which renders it capable of intromission; for I have observed at least one case of vertebral injury in which the penis, although in a state of undoubted priapism that lasted as long as life continued, measured only one inch and a half in length; while after death, when complete relaxation had taken place, it measured two and one-half inches in length. But the foregoing description does not embrace the phenomena that are witnessed in all the cases of priapism arising from spinal injury; for while this description holds good in most cases, there are at least occasional instances of spinal injury in which the priapism amounts to a "strong erection," as was observed in an example already presented for another purpose on page 829. The case, in brief, was that of a stableman, aged 30, having transverse fracture with dislocation of the seventh cervical vertebra, caused by falling down stairs, who was admitted into Bellevue Hospital twenty-three hours after the accident, with complete sensory and voluntary motor paralysis of the lower extremities and trunk up to the third or fourth ribs; also diaphragmatic breathing, retention of urine, etc., and, at the same time, "the penis was strongly erected." This state of vigorous erection must, in great measure, have subsided not very long after admission, for on the third day this entry was made in the clinical record of the case: "priapism always induced by passing the catheter." That night the man died of asphyxia, caused by traumatic, ascending myelitis. Thus it appears that the clinical phenomena of priapism may vary in different cases, or in different periods of the same case, from those of bare turgidity or slight stiffness of the penis, on the one hand, through all the ascending grades of turgidity and stiffness up to strong erections of the organ, on the other.

Another erroneous statement in regard to priapism is frequently made, namely, that it occurs only in cases where the cervical or the upper dorsal vertebræ are fractured or dislocated. But the truth is, that it is also met with not unfrequently in cases where the middle dorsal, or the lower dorsal, or the upper lumbar vertebræ are fractured or dislocated. For instance, I have already related for another purpose, on page 796, the case of a derrick-man, aged 41, who had his tenth dorsal vertebra fractured by being thrown from a cart, and was admitted into Bellevue Hospital two hours after the accident, in a state of profound collapse, with the pulse too frequent and feeble to be counted, and with the lower extremities and body completely paralyzed as to sensation and voluntary motion up to the sixth intercostal space; still, there was moderate priapism observed. I have likewise already mentioned, on page 781, the case of an officer, which was originally reported by Surgeon C. S. Tripler, U. S. Army, and in which there was a shot-fracture of the spinal column at the junction of the dorsal and lumbar regions, attended with paraplegia, retention of urine and feces, and priapism. Furthermore, I have mentioned, on page 743, the case of a man, aged 25 (it was related by Dr. Parker), who sustained a dislocation of the twelfth dorsal upon the first lumbar vertebra, with slight fracture, in consequence of being struck by a falling door, and who had priapism as well as paraplegia; and, no doubt, in several other instances of inferior dorsal or lumbar fractures or dislocations of the vertebræ that are related or referred to above, there was priapism as well as paraplegia present.

In addition to these observations, I will take space only to mention a case reported by Dr. Hutchison,[1] of Brooklyn, N. Y., in which the eighth, ninth, tenth, and eleventh dorsal vertebræ were fractured, in a man, aged 35, by falling fifteen feet from a scaffold, and in which paralysis, priapism, etc., ensued; another case reported by MM. A. Pousson and F. Lalesque,[2] in which a man, aged 40, sustained dislocation of the eleventh dorsal vertebra combined with fracture of its laminæ, and in which, besides paraplegia, there were priapism, etc.; and a third case recorded by Mr. Hilton,[3] in which a man, aged 30, fell through a trap-door, sixteen or eighteen feet, fractured his eleventh dorsal vertebra, and completely divided his spinal cord, with the effect of producing complete paraplegia, etc., as well as priapism, which appeared, however, on the second day. I have no doubt that if a search were specially instituted for the purpose, a considerable number of additional cases could be collected in which fractures or dislocations of the vertebræ in the lower dorsal and lumbar regions were attended by priapism, as well as by paralysis. This peculiar disorder of the male genitalia is, however, met with much more frequently in the cervical and upper dorsal regions than elsewhere, but it should also be borne in mind that fractures and dislocations of the vertebræ occur much the most frequently in these regions.

It may be of interest to remark, in this connection, that Professor Agnew states that he has seen priapism present itself after injuries of the head,[4] as well as after those of the spinal column.

But priapism may likewise appear in cases of *concussion* or *contusion* of the spinal cord, and in consequence of those injuries. I have already presented two examples belonging to this category on pages 790 and 792; one of these was reported by Sir W. Gull, and the other by Mr. Savory. In Sir W. Gull's case, the only lesions of the cord observable were ecchymosis and hyperæmia, mostly in the gray substance, opposite the fourth and fifth cervical vertebræ. The priapism disappeared in a few hours, but returned on the following day. In Mr. Savory's case, there was complete loss of sensation and voluntary motion in the lower extremities, and in the trunk nearly up to the clavicles, the respiration was entirely diaphragmatic, and no reflex action could be excited in the lower extremities or elsewhere; still there was partial priapism. Death occurred in thirty hours; and the autopsy showed a clot of blood in the substance of the cord opposite the fourth cervical vertebra.

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[1] American Medical Times, 1861.

[2] Medical News and Abstract, March, 1881, pp. 179, 180.

[3] Guy's Hospital Reports, 3d series, vol. xi.

[4] Principles and Practice of Surgery, vol. i. p. 829.

Furthermore, priapism may be caused by *inflammation* of the spinal cord. There was a marked degree of priapism observed in a case of acute and very extensive myelitis, terminating fatally in ten or twelve days, that was recorded by Dr. C. B. Radcliffe.[1] Motor and sensory paralysis extended up to a line drawn around the body four inches below the ensiform cartilage. Reflex movements were also absent, but there was retention of urine.[2] Priapism may be an important indication that myelitis is present. Dr. Hammond enumerates among the symptoms of acute myelitis frequent and almost constant erections.[3] Dr. Bramwell in describing the symptoms of acute myelitis states that priapism is often present among them.[4] In Mr. Hilton's case, mentioned above, the priapism which supervened on the second day after the accident probably arose from inflammation of the cord-substance. Thus, we have shown that priapism not unfrequently occurs in cases of concussion, contusion, and inflammation of the spinal cord, as well as in cases of fracture and dislocation of the spinal column; the conclusion to be drawn therefrom is irresistible that the *essential lesion*, or the peculiar pathological condition upon which the occurrence of priapism depends, is seated in the spinal cord, and not in the spinal column nor in the exterior parts.

What is the *essential lesion?* what the physiological apparatus from the disorder of which priapism arises? The fact that the location or site of the essential lesion must be sought for in the spinal cord itself, at once disposes of the theory which ascribes the causation of priapism to lesions of the cervical or dorsal ganglia of the nervi sympathici which lie along the spinal column. It, however, does not dispose of another theory which ascribes the cause of priapism to lesions of those filaments of the nervi sympathici which exist in the spinal cord, and to vaso-motor paralysis of the bloodvessels arising therefrom. Professor Agnew seems inclined to adopt this theory, for he says: "These erections of the penis are not due to action of the muscles, as the latter partake of the general paresis, but are the result of inefficiency of the vaso-motor nerves allowing the blood to flow into the spongy structure of the corpora cavernosa and corpus spongiosum, through the want of resistance in the muscular walls of the vessels."[5] But this theory of erections arising from passive congestion of the penis is untenable, because it utterly fails to account for the rather numerous examples of priapism in which there are strong or even moderate erections observed, and in which the distension of the organ is produced obviously by an active process. Moreover, vaso-motor paralysis is always attended with a notable rise of temperature in the part of the body where it exists, especially if such paralysis be suddenly effected. How, then, can the occurrence of priapism be explained by the theory of vaso-motor paralysis in such instances as the following, which was reported by Mr. Hutchinson,[6] in which "there was marked priapism," but attended with a remarkable depression of the body-heat, both general and local, below the normal standard:—

The patient was a man, aged 24, who fractured his fifth cervical vertebra and severely injured his spinal cord by falling from a ladder with a load of bricks on his shoulder. When seen on the following day, his lower extremities were completely paralyzed, and the line of anæsthesia extended as high as an inch above his nipples. The breathing was solely diaphragmatic. There was marked priapism. The temperature was 98°. The pupils were equal and of a small size in a dull light. Next day the pulse was noted at 36 per minute, and small. In the evening, the temperature in the rectum was only 95.8° ; in the distended penis it was only 93°. He died on the sixth day after the accident. The vaso-motor theory of the production of priapism is insufficient to account for such cases, as well as for those instances in which the erections are more or less vigorous, and in which the distension of the penis is obviously effected by the operation of active agencies.

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[1] Lancet, December 3, 1864.

[2] New Sydenham Soc. Year-Book, 1864, p. 83.

[3] Diseases of the Nervous System, p. 457. New York, 1881.

[4] Diseases of the Spinal Cord, p. 243. New York, 1882.

[5] Op. cit., p. 829.

[6] New Sydenham Soc. Biennial Retrospect, 1873–74, pp. 351, 352.

The nervous apparatus, the disordered action of which produces priapism, is doubtless the same as that by which normal erections are effected. The process is a reflex one, the centre for which (that is, the sexual centre) is situated in the lumbar portion of the spinal cord. The sexual centre may be put into action by peripheral impressions conveyed to it from the penis, especially the glans, by the sensory nerves; also, by cerebral impressions (they are usually emotional influences) conveyed to it by the conducting fibres of the cord. "As the result of the stimulation of the sexual centre, an impulse is generated which travels along the nervi erigentes and inhibits the local nervous mechanism in the bloodvessels of the corpora cavernosa; vascular dilatation, engorgement, and erection follow."[1] Thus, it is not difficult to conceive how priapism may be caused in cases where the spinal cord is injured or diseased in the cervical or dorsal regions, etc., and where paraplegia, both sensory and voluntary-motor, is present in consequence thereof, namely, by irritating the "excitor" fibres which pass from the cerebrum to the reflex sexual centre, as pointed out by Dr. Bramwell.[2] In the same way, cerebral injury or disease may also produce priapism. This view as to the reflex origin of priapism in spinal injuries is supported by a fact noted in the clinical history of a paraplegic case related above, from Bellevue Hospital, viz., that the introduction of a catheter always brought on priapism. Finally, in order to show that the paralysis of the muscular apparatus is not of necessity so complete in cases of seemingly perfect paraplegia that priapism cannot be caused in this way, as asserted by Professor Agnew, it is only necessary to state that, in practice, priapism is very often found associated with retention of urine and feces, and that the presence of the latter condition is due to the fact that the sphincter muscles are not paralyzed.

In regard to the significance of priapism as a symptom, or as a prognostic, in cases of vertebral injury, while it shows that the spinal cord is involved in the lesion, it can be stated with certainty that it is not necessarily a fatal sign, inasmuch as recovery resulted in two cases mentioned above, in which its presence was recorded. One of these cases was reported by Dr. Parker, and the other by Surgeon C. S. Tripler, U. S. Army.

Special treatment is seldom required for priapism. In severe cases, however, pulverized camphor, camphor monobromate, or potassium bromide, may be administered with benefit.

INJURIES OF THE SACRUM AND COCCYX.

FRACTURES OF THE SACRUM.—Simple, uncomplicated fracture of the sacrum sometimes, though very rarely, occurs. The structure, shape, and position of this bone in the skeleton are such as to render it peculiarly free from a liability to sustain solutions of continuity, by itself, in the ordinary accidents of civil life. It is more often found fissured and even comminuted in the severe crushes of the pelvic bones in general, which are not unfrequently met with. In simple, uncomplicated fracture, the lower half of this bone is the part most liable to be found broken, (1) because it is less strong, and (2) because it is more exposed than the upper half.

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[1] Bramwell, op. cit., p. 129.

[2] Ibid., pp. 61, 131.

Specimens illustrating this lesion are exceedingly uncommon in pathological cabinets. The museum of the Royal College of Surgeons, however, contains one example, according to the statements of both Erichsen and South. In it the sacrum is vertically fractured; the patient died of suppuration six weeks after the accident, and no union of the fragments whatever had taken place.[1] Erichsen has seen but one instance. The injury was caused by a blow from the buffer of a railway carriage, and proved rapidly fatal. Not long ago the following remarkable case was observed in Paris:—

A woman, aged 36, was brought into the St. Lazare Hospital with the history of having fallen about eight feet upon her buttocks; she fainted, and, when she became conscious, was quite unable to sit. A slight transverse depression, corresponding to the middle of the sacrum, was readily felt from behind; the injured part was very tender, and pressure gave fine crepitus. Extensive ecchymosis quickly occurred over the whole sacrum. The line of fracture was readily felt also from the rectum and vagina; the projection forward of the lower half of the sacrum was readily verified, and this part of the bone was easily moved, with crepitus. Reduction was effected without difficulty by the finger pressing backward from the front, and displacement did not recur. A bandage was firmly applied round the pelvis and the patient kept in bed. Defecation gave intense pain, and the woman was unable to lie on her back for a fortnight; but she sat up in bed on the twenty-eighth day, and got up in the ward on the forty-second day. There were no signs of pressure upon, or other injury of, the lower sacral or coccygeal nerves.[2]

In this case the sacrum was fractured *transversely;* in the specimen contained in the Royal College of Surgeons Museum, mentioned above, it was fractured *vertically;* it is also stated that this bone may be fractured *obliquely;* but, in simple, uncomplicated cases, these fractures are most commonly transverse.

Etiology.—The most frequent causes of the simple, uncomplicated fractures are powerful blows struck directly over the sacrum, as, for example, a blow from the buffer of a railway carriage; heavy falls with direct impingement upon the sacrum, as was observed in the instance just related; and the sudden application of great weight or pressure, such as may occur, for example, in the passage of a cart-wheel over the sacrum. Great force, when indirectly applied, may also cause such fractures; but the indirect fractures of the sacrum are usually associated with similar lesions of the other pelvic bones, as already intimated. Mr. Erichsen has seen one case of simple, uncomplicated fracture of the sacrum which was caused by a blow from the buffer of a railway carriage, and which rapidly proved fatal.

Symptoms.—The pain in the injured part is usually very acute, and aggravated by all muscular movements which disturb the injured part, such as flexion or extension of the body, etc. All straining efforts in defecation, urination, coughing, or sneezing, produce extreme suffering. All pressure applied externally likewise increases the distress; and the patients themselves will generally have noticed that from the moment of receiving the injury they have been, from this cause, unable to sit upright. On examination, angular deformity may be visible posteriorly, as well as a subcutaneous ecchymosis, which quickly spreads over the whole sacral region. On applying the fingers to the injured part, great tenderness is discovered, together with crepitus and one or more lines of depression corresponding to the fracture and displacement. On introducing a finger into the rectum, and pressing against the coccyx, both crepitus and abnormal mobility may be detected. With a finger of one hand in the rectum and the fingers of the other hand applied externally, the kind and degree of the displacement can for the most part be readily determined. The displacement usually consists in a forward projection of the inferior fragments, as was observed in the example of sacral fracture above related, and is due to the operation of two causes, (1) the blow itself, and (2) the contractions of the gluteus maximus, coccygeus, and sphincter ani muscles. Lateral distortion is not likely to occur, because the lesser and the greater sacro-sciatic ligaments would counteract such a change in the position of the fragments. Moreover, paralysis of the bladder and rectum may likewise be present, inasmuch as both organs receive nerves from the sacral plexus.

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[1] South's Notes to Chelius's System of Surgery, vol. i. p. 595, Am. ed.

[2] Lancet, November 20, 1880.

Prognosis.—Of the three examples mentioned above, two ended in death, and but one in recovery. The successful case, however, shows that when simple fracture of the sacrum is not complicated with other lesions, especially with injuries of the pelvic viscera, the fragments on being placed in apposition readily unite, and recovery speedily ensues; for in that case the union on the twenty-eighth day was already so firm that the patient sat up in bed, resting of course the whole weight of her trunk upon the injured bone in so doing. When, therefore, fractures of the sacrum do not end in recovery, the fatal result is generally due, not to the fractures themselves, but to lesions of the adjacent pelvic viscera with which they are associated. Unhappily, however, any application of force that may suffice to disrupt the sacrum, is very liable to do so much harm to the neighboring pelvic organs, at the same time, as to make a fatal result inevitable. Thus, it appears that the prognosis in sacral fractures depends rather upon their complications than upon the fractures themselves, and that it is generally unfavorable.

When the lesion consists in the breaking off of a layer of bone attached to the cartilage at one or both of the sacro-iliac synchondroses, that is, in modified diastasis, the issue is not of necessity mortal. Dr. Banks[1] has recorded an example of this lesion in which there was displacement upward to the extent of one inch, and still the patient recovered. Moreover, a cure is sometimes obtained in still more unpromising instances, where the fracture is compound, and at the same time complicated with injury of the bladder; for Dr. Burlingham[2] has reported a very remarkable case of compound fracture of the sacrum in which the urine flowed for some time through the wound, and in which, notwithstanding this condition of affairs, the patient entirely recovered.

Treatment.—Fractures of the sacrum should always be reduced when practicable, and the reduction can generally be effected without much difficulty when the fracture is situated in the lower half of the bone (which is the part most liable to be broken), especially if it happen to be transverse. Reduction is to be effected even when the displacement is but slight, because, from the close proximity of the rectum, any displacement whatever of the fragments that might be allowed to remain, would correspondingly tend to irritate that viscus, and to excite suppurative inflammation in the loose connective tissue between it and the injured bone. It should be remembered in this connection that death resulted from such a suppuration, six weeks after the accident, in the case the specimen from which is preserved in the Royal College of Surgeons (mentioned above), and that, as might well be expected under the circumstances, no union of the fragments whatever had taken place. No doubt too the remarkable success which attended the treatment of the illustrative example related above, was mainly due to the fact that the displaced bone was put back again into its normal position without delay, and that an exact apposition of the fragments was uninterruptedly maintained. Oftentimes, reduction can easily be accomplished by pressing upon the displaced bone with a finger in the rectum.

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[1] Atalanta Medical and Surgical Journal, May, 1866.

[2] American Journal of the Medical Sciences, April, 1868.

The second indication in the treatment of sacral fractures is to keep the fragments in apposition. This indication was readily fulfilled in the illustrative example presented above, by firmly applying a bandage around the pelvis, and by keeping the patient in bed. But the main difficulty in the treatment of these cases, where the fracture is the sole injury, is the intense degree of pain with which the act of defecation is accompanied, and the local disturbance which it produces. Some surgeons have, by administering opium, kept the bowels in a state of confinement; and then emptied the rectum every week or ten days by means of an enema. It is, however, still better to diet the patient very carefully with a view to restrain the production of feces to the smallest possible quantity, which may then be easily and almost painlessly removed every three or four days by means of an enema. Whenever pain is present in these cases, it must be subdued by administering opium or morphia in doses that are sufficiently large, and at intervals that are sufficiently brief. Should intra-pelvic inflammation arise, it must be combated by leeches and hot fomentations, as well as by opiates. Should retention of urine be present, catheterization must be employed every eight hours. Should the bladder be wounded in a male patient, but especially should it be ruptured, it may be advisable to open it at once by perineal section in order to allow the urine to escape as fast as secreted, and thus avoid all chance of urinary infiltration. Cases belonging to this category may be saved by the timely performance of this operation, which is not dangerous *per se*, and which, if I remember aright, has already proved successful in one or more examples of this sort, simply because it prevented the pelvic fractures from becoming complicated with urinary infiltration.

But should the broken bone manifest a disposition to slip out of place again after its reduction has been effected, notwithstanding the firm application of a bandage around the pelvis, a mechanical apparatus must be employed to overcome this disposition. For this purpose, M. Indes used simply a piece of wood, cylindrical in shape, five inches in length by three inches in circumference, which was inserted into the rectum, and there retained in position by graduated compresses together with a T-bandage. On every third day this plug or splint was temporarily withdrawn, and the bowel was washed out with an enema. The patient recovered. For the same purpose, M. Bermond used a silver canula, with a bag attached, which when stuffed formed an inner and an outer tampon. The end of the tube was kept closed with a cork, in order to prevent the escape of feces. It was removed only twice during the course of treatment, namely, on the seventh and nineteenth days respectively. This patient also recovered.

The patient should be rigidly confined to bed until the fragments have united. The posture therein should be that which is attended with the smallest amount of discomfort to the patient, and with the smallest liability to the recurrence of displacement.

GUNSHOT FRACTURES OF THE SACRUM.—Hennen mentions three cases in each of which a musket-ball passed through the sacrum, about three inches above the tip of the coccyx, and penetrated obliquely upward. In two of them the rectum was also wounded. In the third, the bladder was perforated as well as the rectum, and "urine passed after the first few hours from the posterior wound." This patient expired on the third day, "laboring under the symptoms of the most violent peritonitis." In each of the other cases the missile lodged, and was passed by stool about two months after the casualty. One of these unfortunate men "survived for two years, when, a discharge of feces coming on through the orifice in the bone, he died, exhausted by a complication of sufferings; but no paralytic affection ever appeared." The remaining case was seen by Dr. Thomson in the military hospital at Berlin, under the care of Dr. Reich, but the result is not stated.[1] From this it would appear that shot fractures of the sacrum are highly dangerous to life. Paré, however, asserted that he had many times seen the sacrum fractured by bullets when the subjects recovered. During the late civil war one hundred and forty-five cases were reported. In three of them the result has not been determined. Of the remaining one hundred and forty-two instances, sixty-two, or 43.7 per cent., were fatal.[2] Thus it appears, (1) that gunshot fractures of the sacrum not unfrequently occur, and (2) that more than one-half of the cases recover.

The following very instructive example eventuated in recovery:—

Lieutenant W. A. C. Ryan, Co. G, 132d New York Volunteers, aged 21, was wounded at Bachelor's Creek, N. C., February 1, 1864, by a conoidal ball, which fractured the last lumbar vertebra, and lodged in the sacrum. He was at once taken to a general hospital where simple dressings were applied to the wound. On June 12, it was noted that the wound discharged very freely; that the patient although feeble was in a very good condition; that an ulcer had formed across the sacrum, about three inches in length by one and a half inches in width, with a sinus leading to the ball; and that the missile was extracted, with some difficulty, from the bone in which it was firmly imbedded, on that day. The wound healed rapidly after the operation. The treatment consisted of tonics, with a generous diet. On October 9, the patient was discharged. There is no record of him at the pension-office.[3] His recovery was, therefore, in all probability complete.

Recovery resulted in the next example also:—

Lieutenant S. W. Russell, Co. B, 49th New York, and A. D. C. Sixth Corps, aged 26, was wounded at Rappahannock Station, November 7, 1863, by a conoidal ball which "entered the left hip, passed across the upper portion of the sacrum, and emerged from the right hip. The surface of the sacrum was fractured." On the 9th he was admitted into Armory Square Hospital, and on February 3, 1864, he was transferred to Seminary Hospital, Georgetown. He returned to duty on May 16 following, where he appears to have remained until June 27, 1865, when he was discharged from the service and pensioned. The pension-examiner noted at the time that the wound was still unhealed. On June 4, 1873, he was still on the pension list.[4]

Among the cases of recovery from shot fractures of the sacrum, reported during the late civil war, were four in which the bladder was penetrated. In nine instances the rectum was wounded, and eight of these cases resulted favorably. In addition to the complications attending shot injuries of the os innominatum, paralysis and other disorders referable to lesions of the nerves were common after shot fractures of the sacrum.[5]

In the cases of shot fracture of the sacrum which were observed during our late civil war, it was common for one or both of the posterior spinous processes of the ilium to be found fractured at the same time, as is shown in the preparation represented by Fig. 797, and as probably happened in the case of Lieutenant Russell, which has just been related.[1]

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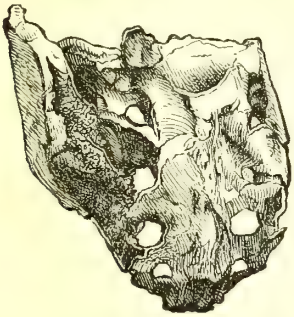
[1] Hennen, op. cit., p. 351.
[2] Medical and Surgical History of the War of the Rebellion, Second Surgical Volume, p. 246.
[3] Ibid., First Surgical Volume, p. 461.
[4] Ibid., Second Surgical Volume, p. 246.
[5] Ibid.

Shot fractures of the sacrum were not unfrequently found by our military surgeons to become complicated with *pyæmia*, as was observed in the following instance:—

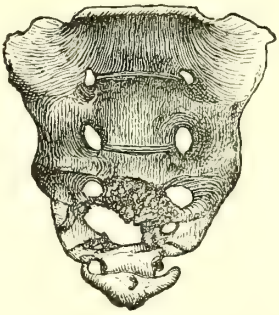
Private George F., aged 23, was wounded at Cold Harbor, June 3, 1864. He was treated in the field hospitals until the 12th, when he was transferred to Washington, and admitted to Douglas Hospital. At this time he was suffering from partial paraplegia. He died from well-marked pyæmia on the 21st, eighteen days after the casualty occurred. *Autopsy.*—The ball was found in two pieces in the sacro-ischiatic notch, having perforated the sacrum to the right of the median line, as shown in the accompanying wood-cut (Fig. 798), which represents the osteological specimen that was obtained from the case, and is now preserved in the Army Medical Museum. Both lungs contained extensive pyæmic patches; the liver and spleen were softened, and the latter enlarged. There had been icterus before death.[2]

Fig. 797.



Shot fracture of the sacrum and ilium. (Spec. 1353, A. M. M.)

Fig. 798.

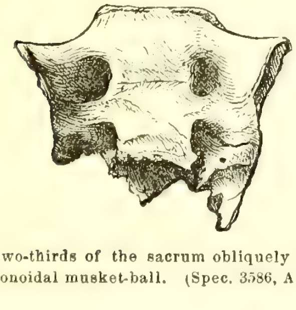


Shot perforation of the sacrum. (Spec. 3568, A. M. M.)

Pyæmia was reported as the cause of death in eight of the sixty-two fatal cases belonging to this category, or 12.9 per cent.[3]

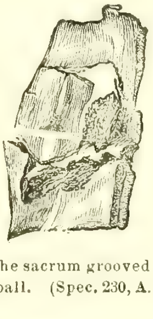
The specimen represented by Fig. 799 was obtained from the corpse of a soldier, aged 41, who was wounded at Petersburg, July 30, 1864, by a conoidal ball. He was admitted to Douglas Hospital on August 3, and died after symptoms characteristic of pyæmia on the 10th, twelve days after the casualty occurred. For three days after

Fig. 799.



Upper two-thirds of the sacrum obliquely fractured by a conoidal musket-ball. (Spec. 3586, A. M. M.)

Fig. 800.



Right half of the sacrum grooved by a conoidal musket-ball. (Spec. 230, A. M. M.)

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[1] Ibid.

[2] Ibid., p. 247.

[3] Ibid.

admission catheterization was required, but after that his water passed freely. There was no other sign of paraplegia.[1]

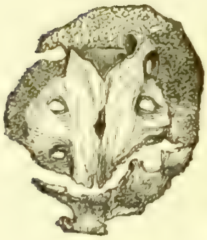
The specimen represented by Fig. 800 was obtained from the cadaver of a soldier, aged 19, who was wounded at West Point, Va., May 7, 1862, and who died in Judiciary Square Hospital, at Washington, on the 23d, with symptoms of pyæmia, sixteen days after the wound had been inflicted. The injury was reported as a "gunshot wound of the lumbar region near the nates, and also through the lower part of the right chest." "*Post-mortem* section of the injured parts showed a deep wound of the sacrum ploughing the bone," as is well shown in the accompanying wood-cut.[2]

In the following instance the sacrum was transversely grooved or perforated by a small-arm missile:—

Corporal Amos E. C., aged 18, was wounded at Chancellorsville, May 3, 1863, by a conoidal musket-ball, which entered the left buttock behind and above the great trochanter, and emerged through the right side of the sacrum. He remained in the hands of the enemy for nine days, during which time his wound was entirely neglected. On June 14 he was sent to Washington, and was admitted to Douglas Hospital in a very nervous, weak, and anæmic condition. There were bed-sores over the projections of the hips, back, and sacrum, so that it was impossible to lay him in a comfortable position. He died on July 9, apparently in consequence of these bed-sores. *Autopsy.*—Pleuritic adhesions were found, but no signs of peritoneal inflammation. The sacrum, as shown in the accompanying wood-cut (Fig. 801), was perforated from side to side, with loss of substance at the junction of the fourth and fifth pieces of the bone. The fragments were carious, and there was a slight osseous deposit on the anterior surface.[3]

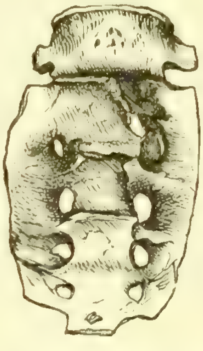
The specimen of shot fracture of the sacrum which is represented by Figs. 802 and 803, was obtained at the autopsy of a soldier, aged 23, with the following history:—

Fig. 801.



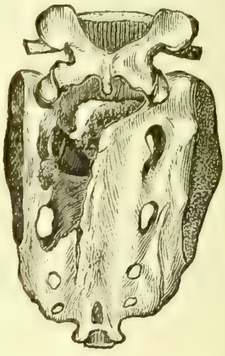
Showing the sacrum grooved transversely by a conoidal musket-ball. (Spec. 1642, A. M. M.)

Fig. 802.



The sacrum and last lumbar vertebra. A ball is impacted in the left upper sacral foramen. (Spec. 2902, A. M. M.)

Fig. 803.



Posterior view of the same specimen.

He was wounded at Spottsylvania, May 10, 1864, and taken to a field hospital of the Fifth Corps. On the 14th he was transferred to Carver Hospital, at Washington. "The missile entered about two inches to the left of the sacrum, passed a little downward and to the right, fractured the sacrum, and remained in the wound. When admitted, the patient was not much emaciated; there was great pain, with tumefaction of the abdomen; the bowels were constipated, and there was complete retention of urine. The bladder was greatly distended with urine; the pulse about 140; the tongue thickly coated with dark-colored fur; sordes on the teeth. There was also partial paraplegia. The catheter was introduced and the bladder relieved. The missile was searched for unsuccessfully. Opiates were then administered. He continued to sink and was perfectly unconscious. The pulse was 160." He died May 15, that is, five days after the wound was inflicted.[1]

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[1] Ibid.

[2] Ibid.

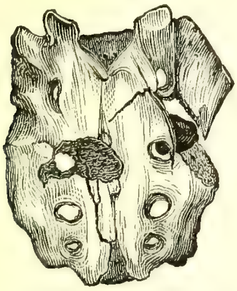
[3] Ibid., p 248.

The cause of death is not stated, but, judging from the symptoms as detailed above, it was traumatic peritonitis. At any rate, peritoneal inflammation must be a frequent consequence of shot wounds such as this. This case is doubly interesting because of the paralysis of the bladder and lower extremities which resulted from the injuries sustained by the sacral nerves.

The following example is very instructive, as well as interesting, because of the peculiar form of paralysis, and the hæmaturia, which resulted from the primary lesion:—

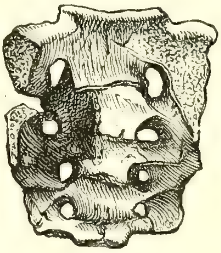
Private Peter K., aged 32, having been wounded at the South Side Railroad, on April 1, 1865, was sent to Washington, and admitted to Douglas Hospital on the 6th. A conoidal musket-ball had entered the left buttock nearly on a level with the second vertebra of the sacrum, about four inches from the spinous process thereof, had passed through or across the sacral portion of the spinal canal, and had lodged in the right wing of the sacrum, near its junction with the ilium. There was complete paralysis of the bladder and rectum, with constant hæmaturia; but no paralysis of the lower extremities. On the 8th, the patient failed rapidly, and became partially insensible. He died on the 9th, from exhaustion, eight days after the casualty occurred.[2] The specimen is represented by the accompanying wood-cut (Fig. 804). The vesico-rectal paralysis observed in this case is easily accounted for; but what caused the hæmaturia? Did it arise from a neuropathic congestion of the kidneys, such as we have seen occurs not unfrequently in cases of spinal injury?

Fig. 804



Showing the sacrum with a ball impacted at the left second intervertebral notch. (Spec. 2542, A. M. M.)

Fig. 805.



Showing a shot fracture of the sacrum. (Spec. 3001, A. M. M.)

In the next case there was a complete transverse fracture observed:—

Private P. McC., aged 20, was wounded at Carrion Crow Bayou, La., November 3, 1863. He was treated on the field until the 8th, when he was admitted to University Hospital, New Orleans, where he died on the 22d, nineteen days after the infliction of the wound. The case is described as a gunshot fracture of the sacrum; "the missile, passing obliquely from the left, entered near the median line at the junction of the second and third sacral vertebræ, and escaped into the pelvis through the right portion of the second vertebra. The sacrum was completely fractured transversely at that point." The specimen is represented by the accompanying wood-cut (Fig. 805).[3]

In the following example, traumatic spinal meningitis with tetanic spasms occurred:—

Private W. M. R., aged 22, was wounded at Winchester, July 20, 1864, by a conoidal musket-ball, which penetrated the sacral region five inches above the anus, and one inch to the left of the median line, passed obliquely upward and forward, and lodged. There was retention of urine, but no paralysis of sensation or voluntary motion. On the 25th he was very restless, and suffered great agony from the wound. But little change was noted until August 6, when slight tetanic spasms, with delirium and unconsciousness, occurred. They continued with increasing severity. On the 8th, opisthotonic spasms recurred at frequent intervals, the pupils were largely dilated and fixed, and he died on that day. *Autopsy.*—The missile was found about three inches from the point of entrance, embedded in muscular tissue. The spinal column was in a suppurating condition. The osteological specimen, represented by Fig. 806, was sent to the Army Medical Museum. It consists of a wedge-shaped portion of the sacrum, showing a fracture into the spinal canal at the second sacral vertebra, with the first and second spinous processes wanting from being broken off.[1]

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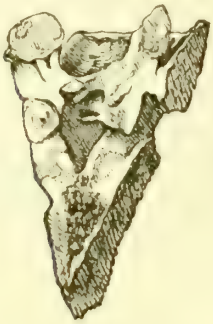
[1] Ibid.

[2] Ibid.

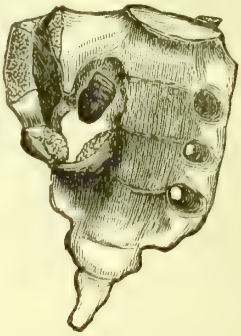
[3] Ibid., p. 249.

Fig. 806.



Showing a shot penetration of the sacral canal. (Spec. 4258, A. M. M.)

Fig. 807.



Showing the sacrum and a part of the right ilium, with the bullet which perforated the former. (Spec. 1245, A. M. M.)

This case, in which the upper part of the sacral canal was opened by a gunshot missile, is a very important one, because traumatic spinal meningitis ensued. The symptoms appeared on the fifth day, and were extreme restlessness, and "great agony" from pain in the wound, followed by tetanic spasms, which steadily increased in severity until opisthotonos followed, with delirium, unconsciousness, and death. The *autopsy* revealed a suppurating condition of the spinal canal. Another instance of shot-fracture of the sacrum in which death resulted from spinal meningitis and myelitis, is likewise reported in the same volume, on page 248. (Case 726.) "The lower part of the spinal cord was softened, and of a dark appearance." In this case, too, the missile after striking the sacrum lodged.

The very interesting specimen which is represented by Fig. 807, was obtained at the autopsy of a soldier, aged 26, who was wounded by a conoidal musket-ball at Chancellorsville, May 3, 1863, and died at Douglas Hospital nineteen days afterward, apparently from septicæmia. The case is also remarkable for the absence of peritonitis and paralysis.[2]

In the next example the missile lodged in the spinal canal, and, notwithstanding that the cauda equina was compressed by it (through the meninges), the sensibility and motility of the lower extremities were not affected :—

Private Michael H. was wounded June 27, 1862, at Gaines's Mills, Virginia, and died of exhaustion on December 27. The wound closed, and there were no symptoms for about three months. On October 20, after dissipation, he complained of pain in the left knee, at times very intense, depriving him of rest. The wound reopened and discharged freely; a slough formed over the lower part of the sacrum, three or four inches in diameter, and so deep as to lay the bone bare. A lumbar and psoas abscess developed itself; the pain in the left knee increased greatly, and the left leg became swollen and tender to pressure. The abscess in the loin was opened by a valvular incision, and three pints of pus were discharged, with great relief to the pain in the leg, etc. Both legs became swollen about December 20, and he died as stated above, exactly six months after the occurrence of the casualty. At no time was there any paralysis of motion or sensation in the lower extremities or elsewhere. *Necroscopy.*—An immense abscess extending from the left kidney to Poupart's ligament was found. In the pelvis, in contact with the sacrum, there was another abcess, while the tissues of the pelvis, at its back part, were buried in effusions of plastic matter. The ball was found lodged in the spinal canal, opposite the fifth lumbar vertebra, as shown in the accompanying wood-cut (Fig. 808). It had entered on the right side of the spinal ridge of the sacrum, about its middle, passed diagonally upward, and spent its force on the left wall of the canal of the first sacral and fifth lumbar vertebræ. The left lamina of the first sacral bone was carried away. The missile had passed up the spinal canal outside of the theca vertebralis. The bodies of the fourth and fifth lumbar vertebræ were carious, and the intervertebral cartilage between them was entirely destroyed. The first and second sacral vertebræ were necrosed and discolored, as was also the fifth throughout its thickness. The first and second left sacral nerves seemed most involved by the diseased bones, but the left lumbar plexus was entangled in the diseased mass which occupied the basin of the pelvis.[1]

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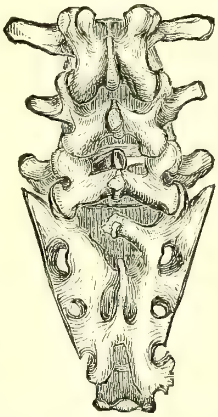
[1] Ibid.

[2] Ibid.

Fig. 808.



Showing the sacrum and last three lumbar vertebræ, with a ball lodged in the spinal canal opposite the fifth lumbar vertebra. (Sp. 1198, A. M. M.)

The complete closure of the wound, and the development of caries and necrosis in the bony structures which had sustained the shock or impact of the missile, after the lapse of three months, are worthy of special remark in this place, as well as the fact that no paralysis whatever occurred.

From the foregoing, it appears that the chief risks which were encountered in treating shot fractures of the sacrum during our civil war, were the supervention of (1) *pyæmia* or *septicæmia*, (2) *traumatic spinal meningitis and myelitis*, (3) *peritonitis*, and (4) *caries and necrosis* of the injured bones, with the formation of corresponding abscesses in the pelvis, as well as in the sacral and lumbar regions.

Treatment.—When the missile lodges, in cases of shot-fracture of the sacrum, it should, if possible, always be extracted. One case has already been related in which this was done with an excellent result. I shall now present two additional cases in which important operations were performed to the same end, with good effect.

Surgeon J. J. Chisolm relates[2] the case of a young Confederate soldier belonging to the 26th Alabama Regiment, who was shot in the back. The missile passed through the sacrum an inch from its spinous processes, and one inch below the level of the crest of the ilium, and lodged. Eight months after the reception of the wound, he applied to Dr. C. for relief, inasmuch as he had a constant discharge of pus from both the wound in the back and a fistulous passage in the left groin. Upon examination with a probe, which penetrated four inches, traversing the sacrum, the foreign body was detected, the bulb of the probe entering the cup of the minié ball. By enlarging the hole through the sacrum with a gouge, room was obtained to draw the ball from the pelvic cavity. The patient recovered.

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[1] Ibid., First Surgical Vol., p. 449.

[2] Manual of Military Surgery, 1863, p. 356.

In the following instance a trephine was applied for the same purpose:—

Private H. F. Norcross, aged 20, was wounded in the right gluteal region, at Drury's Bluff, May 16, 1864. The track of the ball was traced to the second segment of the sacrum, and the missile was apparently embedded deeply in the bone. On March 9, 1865, Dr. E. B. Lyon reported that "there was an open sinus on the right buttock communicating with the lodgment of the ball in the sacrum, and discharging freely. The constitutional condition was comparatively good. Ether was administered, and an oblique incision, six inches in length, was made, exposing the orifice in the sacrum. A trephine was then used to enlarge the orifice in the bone. The ball was divided and removed in seventeen parts. Simple dressings were applied." The wound healed kindly. On July 10, he was discharged from the service and pensioned. In September, 1873, he was still on the pension list, his disability being rated at one-half.[1]

For the removal of injured or diseased bone, or for the extraction of impacted projectiles, there were in all twenty-five operations performed during our civil war, in cases of shot fracture of the sacrum. In one instance, where the missile was discovered "firmly embedded in the body of the sacrum, beyond the reach of forceps, it was extracted by means of a common ramrod, a piece of which remains in the bullet as when taken out." The specimen is represented by the accompanying wood-cut (Fig. 809). It is preserved in the Army Medical Museum.[2]

Fig. 809.

Showing a conoidal ball which was extracted from the sacrum with a ramrod. (Spec. 1123, A. M. M.)

The most important points in the treatment of shot fractures of the sacrum are the following: (1) The removal of all foreign bodies, under which term all loose fragments of bone, all pieces of clothing and accoutrements, etc., as well as the missiles themselves, are included; (2) the application of antiseptic dressings to the wounds; and (3), the early and thorough use of Chassaignac's drainage-tubes. By antisepsis and prompt drainage of the wounds the risk of pyæmia and septicæmia will be greatly lessened. Any tendency to peritonitis or to inflammation of the spinal membranes, which may be evinced, must be combated by administering opium or morphia in full doses at short intervals. Should spinal meningitis supervene, it will require the exhibition of ergot and potassium iodide in full doses, as already pointed out.

SIMPLE FRACTURES OF THE COCCYX.—In the years 1859 and 1860, I made the surgical examination of an old pensioner from the war with Great Britain, of 1812–15, whose disability had resulted from simple fracture of the os coccygis caused by the kick of a horse, and found that bone bent strongly forward and to one side, and rigid in that position. He stated that his injury was still the source of almost constant discomfort, that it always interfered with the act of defecation, and sometimes made it painful, and that it still made it impossible, most of the time, for him to sit while working at his trade of saddler and harness-maker.

Professor Ashhurst[3] mentions a case taken from the records of the Pennsylvania Hospital, in which there was fracture of the coccyx, as well as comminuted fracture of the lumbar vertebræ and fractures of both legs, caused by falling from the sixth story. Death ensued in one day. The *autopsy* showed that the cause of death was internal (post-peritoneal) hemorrhage and exhaustion.

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[1] Medical and Surgical History of the War of the Rebellion, Second Surgical Vol., p. 251.

[2] Ibid.

[3] Op. cit., pp. 116, 117.

Professor Agnew[1] states that he has known a case in which this accident resulted from a rider's coming down upon the back of the saddle in an attempt to mount a restive horse.

Mr. South[2] says he has known two cases where this accident was not recovered from for nearly two years: "The one followed sitting down suddenly on the edge of a snuff-box, which was jammed in between the side of the coccyx and the spine of the haunch bone; and the other by the patient having been thrown from a horse upon a heap of stones. In these cases the pain was not so great as usually said to be in walking, because the patients learned to walk without disturbing the bone; but the pain was agonizing when they incautiously sat down on a soft seat. Leeching afforded only temporary relief; and the cure was at last effected, after months, by protecting the coccyx from all possibility of pressure, by constantly wearing a pair of very thick oblong pads on the ischial tuberosities, so that in sitting the point of the coccyx was in a deep pit."

Simple fractures of the coccyx are said sometimes to occur during parturition, in consequence of the pressure exerted by the fœtal head while passing through the inferior strait of the pelvis; but it is probable that such cases often consist of luxation, or rupture of the coccygeal ligaments, instead of fracture.

This accident is of infrequent occurrence. It may be caused by kicks, by blows, by falls, and by injuries sustained during parturition. Though seemingly a very trivial accident, it is often exceedingly painful and annoying for many months or years, or even for a lifetime.

The displacement in fracture of the coccyx is forward, and it is produced by the same agencies as those which cause the deformity in simple fracture of the sacrum, namely, the contractions of the muscles which are inserted into the coccyx, as well as the general direction of the fracturing force.

Treatment.—Although the injury at first sight may appear inconsiderable, the victims of this accident, for reasons presented above, should always be confined to bed, in that posture which is least painful, and which causes least disturbance of the injured bone. Any forward displacement should be corrected by inserting a finger, well oiled, into the rectum, and pressing the bone back into its normal position. If the deformity returns, it may become advisable to employ such tampons as have been described while discussing fractures of the sacrum. Should much inflammation supervene in the injured part, the application of leeches, followed by a lotion composed of lead-water and laudanum, will prove useful in subduing the inflammatory action, and in diminishing the liability to the occurrence of neuralgia, necrosis, abscess, and fistula. Should, however, the ligamentous tissue surrounding the bone continue inflamed and painful, notwithstanding the treatment, and especially should the apex of the injured bone be incessantly dragged forward by spasmodic action of the sphincter ani and other muscles which are inserted into the os coccygis, it may be proper to forcibly stretch the sphincter, under ether, as in cases of anal fissure, so that the fibres of that muscle may be paralyzed for a time, and that defecation may take place without spasm and without restraint. After such patients leave their beds, it will often be useful for them to protect the coccyx from injury by constantly wearing a pair of thick oblong pads on the tuberosities of the ischium, as recommended by Mr. South.

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[1] Op. cit., vol. i. p. 923.

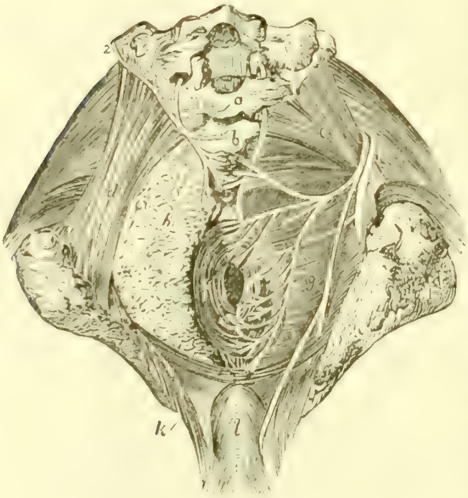
[2] Notes to Chelius's Surgery, vol. i. pp. 595, 596, Am. ed.

Gunshot Fractures of the Coccyx.—In shot wounds of this sort, the lesion of the bone is commonly but a small part of the whole injury. There were seventeen cases of shot fracture of the os coccygis reported during our civil war, of which six, or 35.3 per cent., were fatal. In twelve cases, with five deaths, the coccyx was the only bone involved; in four cases, terminating favorably, there were attendant fractures of the sacrum; two, one of which was fatal, were associated with fractures of the pubis. In one case a ball is said to have been found imbedded in the coccyx. In all the fatal cases, death appears to have resulted from the injuries sustained by other parts. Still, visceral lesions were less frequently present as complications of shot fractures of this bone, than would be anticipated from its anatomical relations.[1]

In regard to *treatment*, the irregularity and variety of the complications preclude the establishment of any special rules. The early removal of sequestra and foreign bodies is, of course, indispensable. Free though cautiously directed incisions may be requisite to prevent the burrowing of pus. Extreme attention to cleanliness, and to the prevention of fecal accumulation in the rectum, as well as watchfulness over the state of the bladder, are precautions that must not be overlooked.[2] The wounds must be dressed antiseptically, and drainage tubes must likewise be inserted, in many cases, in order to insure that no confinement of inflammatory products shall take place.

Coccygodynia.—The damage sustained by the sacro-coccygeal and other spinal nerves, in connection with injuries of the os coccygis, often gives rise to an exceedingly painful state of the soft parts overlying the bone, which has been denominated *coccygodynia*. The accompanying wood-cut (Fig. 810), which indicates the numerous nerves of sensation that are distributed over the coccyx, and to the lower part of the rectum as well as to the margin of the anal aperture, shows at a glance the anatomical and physiological explanation of this distressing affection.

Fig. 810.



a, Sacrum. *b*, Coccyx. *c*, Tuberosity of ischium. *d*, Greater sacro-sciatic ligament. *e*, Lesser sacro-sciatic ligament, with pudic nerve on its posterior aspect. *f*, Sphincter ani. *g*, Levator ani. *h*, Fatty and connective tissue.

1, Pudic nerve and its branches.

2, Posterior branches of the 2d, 3d, and 4th sacral nerves proceeding to posterior aspect of the coccyx.

3, Sacro-coccygeal nerve distributed over apex of the coccyx and adjacent soft parts. (Hilton.)

For the relief of coccygodynia, it was advised by the late Sir James Y. Simpson, to introduce a narrow bistoury between the soft parts and the bone, and completely sever the connections between them. Should this simple procedure fail, and the symptoms continue severe, it may be necessary to excise the bone itself. When caries or necrosis is present, excision of the bone is always necessary.

In regard to operative procedures, Van Onsenoort and Ollier have extirpated the coccyx for caries, and Nott, Simpson, and many others have performed the same operation with impunity for neuralgia (coccygodynia).

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[1] Medical and Surgical History of the War of the Rebellion, Second Surgical Vol., pp. 252, 253.

[2] Ibid., 253, 254.

Dr. James E. Garretson[1] has proposed and successfully performed the operation of removing the coccyx without disturbing the perineal anatomy, by the employment of a dental engine. This operation was done at Penn Manor, on the person of a lady who had suffered from coccygodynia for thirteen years. Exposure of the coccyx revealed it as fractured and standing at right angles with the sacrum. Dr. Garretson's proposition was to remove the bone by simple enucleation; in other words, to remove the osseous tissue from its envelope of periosteum without disturbing the under layer thereof which is the surface of attachment for the soft parts constituting the posterior perineum, and, of course, without disturbing the relations of the structures which constitute the perineum itself. The operation was performed in the following manner:—

The patient being etherized and placed partially upon her abdomen, an arm being under the body at the region of the diaphragm, to secure freedom in respiration, an incision was made through the skin and superficial fascia, the length of the coccyx. These tissues being carried to either side by means of retractors, a second incision was made through the periosteum, and by means of a chisel-shaped knife this structure was raised and everted. In this last is the peculiarity of the operation: it is as though one might cut down the centre of the upper surface of an envelope, exposing, in the turning aside of the paper, a letter lying on the lower face of the envelope, the turned-aside upper part being of continuity with the bottom of the paper. A succeeding step employs the engine. A circular burr, the face side alone of which is cut, is placed in the grasp of the handpiece, and while in revolution to the extent of ten thousand times to the minute, is applied, with delicacy of manipulative touch, to the surface of the bone. In the case here recorded, five minutes sufficed for the disappearance of the coccyx in the shape of bone dust, the under face of the periosteum remaining as undisturbed as though it had never been in relation with the coccyx. The wound, a superficial one, was put up to heal by first intention.

I believe this operation to be a very good one, and therefore I have taken the space requisite to describe it.

Remote Effects of Spinal Injuries, Railway Spine, etc.

When *fractures* or *dislocations* of the spinal column eventuate in recovery, there occurs, as a rule, anchylosis, with immobility or inflexibility of the injured part of the column. Any vertebral displacement which may have been allowed to remain will constitute a deformity. Among the remote effects of spinal fractures and dislocations, *anchylosis*, *stiffness* or *inflexibility*, and *deformity* must therefore be enumerated. In cases where the cervical portion of the column has been thus injured, the inflexibility and deformity may cause much inconvenience in many ways, and may also interfere, seriously and persistently, with the act of swallowing. These points are well illustrated by the following case:—

George Reid, aged 29, a tailor, was admitted into Bellevue Hospital (Dr. Stephen Smith's Ward) on August 5, 1858, for cephalalgia, the result of an injury. He was short in stature, but well made and well nourished, and free from constitutional taint and tendency.

Upon external examination, the fifth cervical vertebra, its spinous process, etc., were found displaced forward; upon examination through the mouth, the body of this vertebra was felt projecting forward, and forming a large prominence in the pharynx. He was unable to swallow solid food to any considerable extent. This dysphagia and the necessarily awkward position in which he was forced to carry his head were the only local difficulties now present, which resulted from the vertebral displacement. The vertebræ themselves were firmly fixed in their new position. His general health was good.

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[1] Annals of Anatomy and Surgery, March, 1882.

History.—In September, 1856, the patient fell backward down fifteen stairs, and struck upon the back of his head and neck. He was rendered insensible, and remained so for three hours. He has never been able to recollect anything in regard to his fall, his memory otherwise being unimpaired. There was no wound nor contusion, nor any other external evidence of injury upon his neck. With returning consciousness he did not become aware of his injury until he attempted to rise from the bed. He then felt an acute, spasmodic pain in the back of his neck, which subsided immediately on lying down again. This pain in the back of his neck, on motion, continued three months. Three weeks subsequent to the accident, he began to have severe pain in the back of his head—usually nocturnal—and at that time was admitted to this hospital in the service of Dr. Charles D. Smith. Excepting the pains just mentioned, and dysphagia, he has not had any subjective symptoms of spinal injury. There have been no anæsthesia, no paralysis, no difficulty in breathing, micturating, or defecating, and no increase of temperature.

His general health being good, he was discharged as affording no particular indication for treatment.[1]

The "awkward position" mentioned above in which the patient was compelled to carry his head is not described in words, but it was doubtless the following: Inasmuch as the original lesion of the spinal column consisted in a forward dislocation of the body of the fifth cervical vertebra upon that of the sixth, there occurred in consequence of the action of the muscles directly or indirectly involved, together with the superimposed weight of the head, a forward bend in the spinal column at the place of injury, which widely separated the spinous process of the fifth cervical vertebra from that of the sixth, and likewise caused the neck and head to present a "thrust-forward" appearance, as well as to acquire a "thrust-forward" position. It certainly must have been very awkward for the patient to carry his head always in that manner. And had the deformity been removed at the outset by reducing the dislocation, it would have been much better for the patient, because by so doing his difficulty in swallowing would have been obviated, and his head would have been placed in a much more comfortable position.

The pain in the back part of this patient's neck and head which followed the accident, and still persisted two years afterward in a troublesome or distressful degree, was probably due to meningeal irritation, or a low grade of meningeal inflammation, which itself resulted from the fact that the dislocation was not reduced, and that the theca vertebralis was consequently stretched and irritated by the injured vertebræ in their abnormal positions. Thus it appears that pains arising from *meningeal irritation* and *inflammation* (both spinal and cerebral) must also be enumerated among the remote effects of vertebral fractures and dislocations. Moreover, much difficulty will often be experienced in controlling this meningeal disorder, unless perchance the causal indication in its treatment has previously been fulfilled, by "setting" the fractured or dislocated vertebræ, and thus removing the displacement upon which its existence mainly depends. The remedial measures to be employed in such cases are dry cupping and setons, together with the administration of potassium iodide in full doses, alternated with corrosive sublimate, for a long period.

Among the remote effects of *sprains*, *wrenches*, and *twists* of the spinal column, are chronic *inflammation of the vertebral joints* that are implicated, which is often suppurative in character, *destruction of the articular cartilages* and the *intervertebral substances* that are involved, and *caries* or *necrosis* of the adjoining vertebral bodies. In such cases, the destructive process begins more frequently at the junction of the vertebræ with the intervertebral substances than in the intervertebral substances or vertebræ themselves, because, as Mr. Hilton has pointed out, we know that in accidents, at least as far as we have been able to discover, "the most frequent lesion in injury to the spine is a partial severance of the vertebra from the intervertebral substance."[1]

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[1] New York Journal of Medicine, March, 1859, p. 246.

A number of illustrative examples have already been presented,[2] and inasmuch as this topic has already been pretty thoroughly discussed, no apparent need exists for presenting any additional instances of the same sort. I will, however, take space to present a very instructive case, in which there simultaneously occurred lumbo-sacral abscess and suppurative spinal meningitis, in consequence of a blow on the spinal column:—

A lad, aged 15, employed with his parents in a travelling show, was in good health until May 12, 1856, when, while playing with another lad, he received a blow on the back with the fist. He thought little of it at the time; but, subsequently, the pain becoming severe, he applied for and obtained admission into Guy's Hospital on May 15. After the application of leeches he was so much relieved that he thought of going out, but the pain soon returned more severely, and fever ensued. An abscess formed on the right side of the sacrum, which was opened, and continued to discharge, the flow of pus being increased by pressure on the abdomen. He continued to get worse daily, having much irritative fever and severe pain in the back. During the last week of his life he was exceedingly restless, and often delirious; and he complained of pain in all parts of his body, but particularly in the extremities. His head was generally drawn backward as in tetanic opisthotonos. On one or two occasions he had loss of power over the bladder and rectum, but had no other symptoms of paraplegia, and could move freely in bed. On June 4 he died, twenty-two days after the casualty, and nineteen days after entering the hospital.

Autopsy.—An aperture in the integuments at the right side of the sacrum led into a very extensive abscess, external to the peritoneum, which occupied the forepart of the sacrum behind the rectum, and extended to the ilia on both sides behind the psoas muscles. The bones were exposed but not diseased. Although the abscess had discharged externally on the right, it was most extensive on the left. It had burrowed up to the left side of the last lumbar vertebra, and through the sacro-vertebral foramen into the spinal canal. When the theca was opened, it was found to contain a quantity of greenish pus, spread over its inner surface and over the cord itself. The spinal dura mater (theca) at the point indicated, was softened and destroyed, and the cauda equina was lying bathed in the pus which filled the sacral canal. The membranes of the cord were inflamed throughout their whole extent, and there was purulent effusion as high as the dorsal region. The spinal dura mater was thickened, its inner surface had lost its smoothness and transparency, and was of a dull-green color. Pus could be squeezed out from beneath the visceral arachnoid in considerable quantity. The spinal cord itself was firm, and the microscope revealed no morbid condition in its substance. On opening the cranium, traces of acute arachnitis were found over the whole surface of the brain, greenish-colored lymph being effused into the sub-arachnoid tissue, especially at the base. The inner surface of the dura mater, around the foramen magnum and on the adjacent part of the occipital fossa, was of a greenish color, from lymph effused upon it. Bronchial tubes filled with tenacious mucus. Lumbar and bronchial glands slightly enlarged. All other organs entirely healthy.[3]

The purulent infiltration of the spinal meninges which was observed in this case, occurring coincidently with the formation of a lumbo-sacral abscess, but without the production of paralysis, could scarcely have happened unless the sacro-vertebral articulation had previously been opened, both externally and internally, by disease of the articulation itself, in such a manner as to allow the products of inflammatory action to flow freely out of, as well as into, the spinal canal. Otherwise, the suppurative meningitis would pretty certainly have caused paralysis by compressing the spinal cord with the inflammatory products.

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[1] Op. cit., pp. 47, 48.

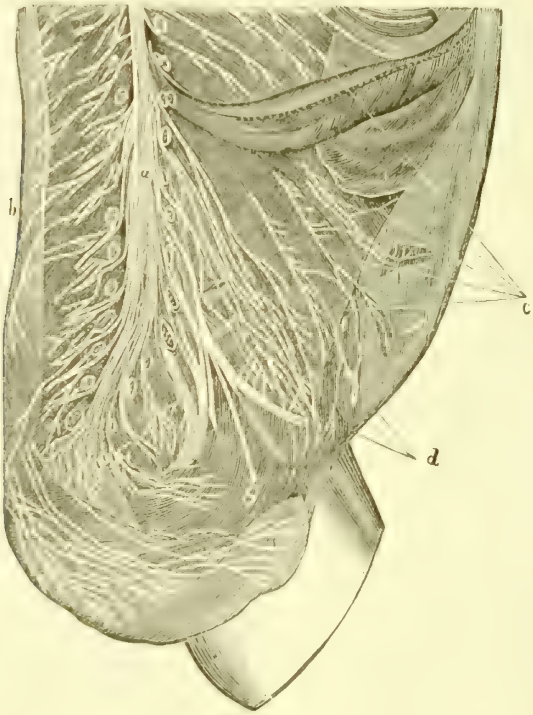
[2] See pp. 686–709 *supra.*

[3] Guy's Hospital Reports, 1856, pp. 158, 159.

The clinical history of this lad's case, interpreted by the post-mortem appearances, appears to have been as follows: The blow on his back wrenched the sacro-vertebral articulation, and caused a suppurative inflammation to be lighted up therein, particularly on the left side, and in consequence of this, purulent matter escaped in an outward direction, and led to the formation of an immense lumbo-sacral abscess; it likewise escaped in an inward direction, and caused the theca vertebralis to become softened and perforated, and extensively destroyed, and a diffuse suppurative inflammation, which extended upward to the brain, to be kindled in the spinal arachnoid. Moreover, the account of the case presented above gives the symptoms by which each of these periods, or stages, in the progress of the case was characterized.

The symptoms indicative of the joint inflammation were pain in and soreness of the joint itself, and these were to some extent relieved by leeching. The formation of the lumbo-sacral abscess was attended by a return of the joint-pain, followed by pyrexia, and by the appearance of a swelling which, on being opened, discharged purulent matter. The spinal meningitis set in with severe pain in the spinal column, and irritative fever, followed by extreme

Fig. 811.



Showing the lower part of the spinal cord, and the distribution in the trunk of the corresponding spinal nerves. (Swan.) *a*, The spinal cord. *b*, The posterior branches of the spinal nerves, proceeding to the muscles and integuments of the loins, etc. *c*, The radiating lines indicate the anterior branches of certain dorsal nerves which are distributed to the muscles and integuments of the upper half of the abdominal walls. *d*, The anterior branches of the lumbar nerves which are distributed to the lower part of the abdominal walls. *ee*, Anterior part of the abdominal walls. *f*, The rectus abdominis muscle. *g*, The obturator nerve. *h*, The diaphragm. (Hilton.)

restlessness and general hyperæsthesia of a severe character. Tetanic spasms and opisthotonos ensued.

The remote effects of spinal injuries are to be still further traced in the occurrence of *chronic spinal arachnitis* of a fatal character, without the supervention of any vertebral joint inflammation whatever.

Sir W. Gull has recorded the following instructive case of traumatic, chronic, spinal arachnitis:—[1]

A railway porter, aged 22, strong and muscular, had his neck and shoulders squeezed between the buffers of two carriages, on September 20, 1855. For three or four weeks afterward, he was unable to work, and felt much pain in the right arm, as also in the scapular region and down the back, especially between the seventh and tenth dorsal vertebræ. The pain was increased by any sudden twist of the body, and extended to the abdomen. About the first of February, 1856, he was again obliged to quit work, on account of the severity of the pain along the spine. On Feb. 6, he was admitted to the hospital under Dr. Addison's care. There were pain on pressure over the lower dorsal vertebræ, pain in the abdomen, and occasional tingling in the hands and feet. The abdomen itself was full and hard, with pain on suddenly turning the back, extending from the ribs below the umbilicus. Nothing abnormal was found in the chest; pulse 78; tongue furred in the centre; bowels regular; appetite defective. He was treated by cupping, mercurials, and laxatives. On the 11th, the pain in the back was increased He also had headache, and his nights were restless and disturbed by dreams. The shooting pain in the abdomen continued, and it was noted that the integuments were remarkably hot and dry. The pulse was 72, with a noticeable sharpness in the beat. From this date he became slightly affected by mercurial action, and was apparently improving. He left his bed for several hours in the day, without inconvenience; still, however, complaining of his former symptoms, and of pain through the chest. On the 28th he had general febrile symptoms, with cough, and hurried breathing, and signs of pleurisy at the base of left lung. The abdomen was tense; constipation; pulse 112; sleep disturbed by dreams, and by frequent spasmodic twitchings of the extremities. He complained very much of pain in the lumbar region, on each side of the vertebral column, and down the sacrum. On March 11, there was retention of urine. On the 13th, slight delirium, and a marked decline of strength. He was scarcely able to move his legs, but the sensation on pinching was acute. He lay supine, sinking to the foot of the bed, his arms being too weak to help him to support himself. From this date he rapidly became worse, with much cerebral oppression. The urine drawn off daily by the catheter was ammoniacal, with large deposit of phosphates The feces escaped involuntarily. Frequent convulsive twitchings, both of the upper and lower extremities. Breathing hurried and laborious. Tongue dry and brown. Pulse 108 On the day before death, he lay nearly insensible, frequently moaning and sighing, pulse 90, feeble and irregular; urine copious, and drawn off by catheter; feces passed involuntarily. On the 17th he died, about six months after the accident

Autopsy.—No injury of the vertebræ or ribs was discovered; spinal canal and external surface of the spinal dura mater healthy. On opening the dura mater, the spinal arachnoid appeared remarkably thickened and flocculent, from the effusion of lymph beneath it. The effusion was greatest on the posterior surface of the cord along the median line, but at the lower part of the cord (a segment of it corresponding to the lower cervical and eighth upper dorsal vertebræ only was allowed by the friends to be examined), the effusion extended around it to the anterior surface, and upward for a short distance. The cord itself was not softened; and, on repeated microscopical examination of the cord-substance, at different sections, no traces of exudation were discovered. The theca vertebralis had undergone no alteration, excepting that the inner layer was rather opalescent. One or two very small fibroid plates on the visceral arachnoid. The flocculent effusion covering the cord (that is, found in the meshes of the pia mater), presented under the microscope the usual appearances of inflammatory exudation on serous surfaces in the stage of organization into permanent adhesions. Examination of head not allowed. Old adhesions over the surface of the upper lobes of both lungs. At lower part of left chest, about a cupful of purulent fluid was found. Parenchyma of both lungs stuffed with softish, yellow, miliary tubercles, equally diffused from apex to base. Kidneys large; their cortical portion studded with miliary tubercles. The splenic tissue similarly affected. Heart and liver healthy.

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[1] Guy's Hospital Reports, 1856, pp 156, 157.

The phenomena of subacute, traumatic, spinal meningitis, when it runs a chronic course to a fatal termination, are well shown by this case. The symptoms characteristic of the disease were pain in the affected part of the spinal column, increased by suddenly twisting or bending it; also pain felt in the peripheral extremities of all the spinal nerves issuing from the affected part of the spinal column, particularly in the abdomen, in the loins, and in the lower extremities. The abdominal pain was attended with hot and dry integuments, and probably, if carefully looked for, oscillations of temperature would have been observed. These peripheral pains arise from the excitation of the sensory filaments of the corresponding spinal nerves by the inflammatory action that is going on, within the spinal canal, in the membranes of the cord adjoining their roots; for instance, in cases where such peripheral pains are felt at the epigastrium, the sensory filaments of the sixth or seventh dorsal nerves are excited by the inflammatory process in the spinal arachnoid and pia mater investing them before they enter the intervertebral foramina. When the sensory filaments of the eighth or ninth dorsal nerves are irritated in this manner, the peripheral pains are felt lower down in the abdominal walls, in the parts thereof which are supplied by the irritated nerve-fibres; and when the sensory filaments of the remaining dorsal, or of the lumbar nerves, are excited in a similar manner, the peripheral pains are felt still lower down, in the respective terminal extremities of the excited nerve-filaments. Excitation (intra-spinal) of the motor filaments of the spinal nerves arising from the same cause, in this case, was denoted "by frequent spasmodic twitchings of the extremities," by the "tense" and "hard" condition of the abdominal muscles which arose from tetanoid (tonic) spasm thereof, and by the persistently stiff or contracted feeling in the muscles of the extremities, particularly the lower ones, which doubtless was present, and would have been revealed by asking the patient about it.

The altered sensations of the patient in this case, the "tingling" and the "numbness" in his feet and hands, and the acute sensation produced by "pinching" his legs (hyperæsthesia) after paraplegia had set in, were due either to inflammatory excitation of the cord-substance by the contiguous membranes, or to compression of the cord-substance by the inflammatory products effused in the meshes of the spinal pia mater. The vesical paralysis, the alkaline urine, the anæsthesia (insensibility) and motor paralysis (or paraplegia) which appeared near his end, were caused by compression of the cord-substance effected in the way just mentioned.

The inflammatory effusion was found at the autopsy of this case, as usual, under the so-called visceral layer of the spinal arachnoid alone, that is, in the interstices of the pia mater, but principally on the posterior surface of the cord, to which it had probably settled by gravitation. The exudation itself did not contain pus-corpuscules, and would have been capable of becoming organized, if it had not caused death by its quantity, and by the compression which it exerted upon the cord substance. The tubercular infiltration of the pulmonary, renal, and splenic tissues, which was revealed by the autopsy, must be held to have probably resulted from the pathological state of the spinal cord-substance.

But, among the remote effects of spinal injuries, chronic spinal meningitis, combined with *chronic myelitis*, and running their joint course *pari passu*, must likewise be mentioned. The following example will serve to illustrate the phenomena of traumatic spinal meningitis and myelitis, when they are subacute, and run a chronic course together to a fatal ending.

Sir W. Gull[1] relates the case of a coal wagoner, aged 49, who was forced backward from his seat by striking his head against a beam, whilst driving under an archway; several ribs on the left side were fractured. Some months afterward, he began to suffer pain extending from the occiput down over the shoulders; and, in about a year, the muscles of the upper extremities began to waste. After two years, incontinence of urine gradually came on. He was admitted to Guy's Hospital, February 11, 1857, three years after the accident. He then presented a remarkable example of muscular atrophy without actual paralysis. The upper extremities were principally affected. The extensors of the right hand, the muscles of the thumb, and the interossei were extremely wasted. The wrist dropped. The muscles of the shoulder and arm, including the pectoralis major and minor, were much wasted, but in a marked degree less so than those of the forearm and hand. Very slight diminution of sensation. He could still lift the arm over the head. The left arm was similarly, but less affected than the right, as far as regarded muscular atrophy, but there was numbness through the whole arm down to the fingers, and the patient suffered severely from neuralgic pains in it which greatly depressed him, and which he described as a compound of smarting and numbness. The trapezii, serrati postici superiores, rhomboidei, and all the long muscles of the neck and back, were remarkably atrophied. The spinous processes were very prominent. No deformity nor tenderness on pressure at any point. The intercostals were so weak that the only respiratory movement was through the diaphragm. The supra-spinati were atrophied, but not to the same extent as the infra-spinati and the levatores angulorum scapularum. The legs were wasted and weak, but he was able to walk. Sphincter weak. Dribbling of urine. Constipation. The thorax looked narrow and ill-developed from the wasting of the pectorals, the intercostals, and the erectores spinæ muscles. The muscles of the back of the neck, and the sterno-mastoids, were so weak that the head could not be supported erect. Sight dim; drooping of left eyelid. Frequent hiccough for many months. After admission, his principal complaint was of pain in the left arm from the clavicle to the fingers. He described it as a severe smarting with a sense of numbness. His distress from this cause was very great. Early in March, febrile symptoms set in; tongue became dry and brown; frequent hiccough and vomiting; pain in left arm severe. On March 25th, he died, more than three years after the accident

Autopsy.—The cranial arachnoid was opalescent, with spots of white, from fatty degeneration, mottling the more opaque parts; subarachnoid fluid in excess; ependyma of lateral and fourth ventricles granular, in the latter extremely so.

The spinal dura mater was much thickened on the posterior surface of the cord; the arachnoid adhered to it in patches along this surface, and was much thickened by the effusion of lymph of an old date. Sections of the cord, examined with the naked eye, gave no distinct evidence of disease There was a slight yellowishness of the posterior columns, with increased vascularity and thickening of the pia mater covering them. In these columns, but especially in the right one, an abundance of granule cells was discovered by the microscope. The exudation was greatest in the middle and lower thirds of the cervical enlargement The gray substance was hyperæmic. No exudation into its tissue, nor into the anterior columns. The ventricle of the cord was enlarged and distended with delicate granular nuclei. The affection of the cord appeared to be secondary to chronic inflammation of its membranes, and to chronic changes in the ependyma of its ventricle occurring in common with changes in the ependyma of the fourth and lateral ventricles of the brain. Hypostatic congestion of both lungs, several lobules consolidated from recent pneumonia, some grayish. Other organs healthy.

The phenomena attributable to myelitis which presented themselves in this case were rather peculiar, and consisted of blunted sensibility (anæsthesia), paralysis of the sphincters with obstinate constipation, diminished motility

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[1] Guy's Hospital Reports, 1858, pp. 194, 195.

(voluntary-motor paralysis), and muscular atrophy. The hiccough and vomiting, which were frequently observed for many months in this case, were probably dependent upon the origin, distribution, and connections of the phrenic nerves, and arose partly from disease of the membranes, and partly from disease of the cord-substance, in the cervical region.

In regard to the *muscular atrophy*, which was progressive and exceedingly well marked, it also must be looked upon as one of the remote effects of spinal injury, resulting directly, however, from inflammatory irritation of the posterior columns and gray substance of the spinal cord. The attentive reader will doubtless have already observed that, in the case just related, the gray substance was found to be hyperæmic at the autopsy, and that the posterior columns, but especially the right one, exhibited structural changes of a distinctly inflammatory character

This variety of muscular atrophy was formerly regarded as a primary affection of the muscles themselves. Its origin, however, really lies in certain morbid alterations which have taken place in the gray substance of the spinal cord, particularly the anterior cornua thereof.

I shall next present a remarkable example which will prove very useful in the way of exhibiting progressive muscular atrophy and chronic inflammation of the rachidian substance as remote effects of spinal injuries, such, for example, as concussions of the spinal cord that are thought nothing of at the time when they are received; and, what is of greater importance, it will serve to show how difficult it sometimes may be for even the most skilful observer to make a correct diagnosis as to the essential lesion in such cases. In this example an erroneous opinion was entertained as to the nature of the disease, until this was revealed by the autopsy.

Sir W. Gull has related the following very instructive case of chronic myelitis, involving first, as well as most markedly, the cervical portion of the cord, and arising from concussion thereof produced by a blow on the neck:—[1]

A steamboat-stoker, aged 23, intemperate but healthy, was admitted into the hospital, June 5, 1851. Five years before, he had been struck in a pugilistic combat, unexpectedly and severely, "by another man's fist on the side of the neck, near the articulation of the skull with the vertebral column. Since that he has occasionally had difficulty in deglutition, particularly of fluids, which would be expelled through the nose. For the last year he has had a choking sensation; and, at times, difficulty in passing water." Meanwhile, his right arm became weak and wasted, from the shoulder downward, which he ignorantly attributed to an injury of the back of his right hand by the falling of a piece of iron. He continued to work with his left arm for three months longer; but, about 1850, he began to suffer from what he termed "bile," that is, frequent vomiting, unattended by any pain in the head, or giddiness. These attacks of vomiting continued to return for four months; and then, as they subsided, there was increased difficulty of deglutition, and both legs became weak, the left first, and to the greatest degree. In the autumn he improved, and was able to walk about, but the bladder was so far paralyzed that he needed the catheter to be passed for several weeks. The improvement, however, was only of short duration. When admitted into hospital, his right arm was completely paralyzed at the shoulder-joint, and there was great wasting of the muscles; only slight power of moving the fingers remained. There was anæsthesia, increasing toward the hand, but most marked in the branches of the ulnar nerve No actual paralysis of the left arm, but the muscles were flaccid and weak. He had pains running over the back of his head. He could move his legs slightly. Sensation impaired as high as the hips. No deformity of the spine, nor tenderness on percussion. No sense of constriction at any part of the trunk. Vision somewhat impaired. Urine and feces passed involuntarily. Pulse 90. Tongue clean and pale. He improved, by rest and by the use of electricity, so far that, in October, he could support himself and walk without help, though his gate was very vacillating, from want of power to direct the muscles. No numbness remained in the legs. The right arm continued in the same state as on admission. The left arm was weak, and, at times, he had cramp in the muscles, and involuntary closure of the hand. The sphincter partially paralyzed. Aspect pale and emaciated; the whole muscular system much atrophied. He remained in the hospital until June, 1852, his symptoms fluctuating between improvement and relapse. He could walk about the ward by the aid of a stick, with a feeble gait, his right arm hanging loosely, supported only by the ligaments of the shoulder-joint. In October, 1852, he was readmitted to the hospital. In a few weeks afterward, the left arm was quite paralyzed, and he lost the little remaining power over the sphincters and legs, and became universally paraplegic. He often complained of a sharp pain in the back of the head, and in the upper part of the neck. On January 19, 1853, bronchitis supervened, from exposure in moving him from one ward to another; though trifling in degree, the distress occasioned by it was inexpressible, owing to paralysis of the intercostals [and inability to raise the phlegm by coughing]. A remission of his chest-symptoms occurred until March 14, when they again became aggravated. His distress was indescribable. Ineffectual efforts to expectorate were constantly made; pulse, 120; respiration, 36; face congested. There was complete paralysis of the walls of the chest, as well as of the extremities, and general anæsthesia, yet great pain when the body or limbs were roughly handled (hyperæsthesia). Frequent spasms in the legs; arms not so affected. Urine constantly dribbling. The integuments over the sacrum became slightly abraded, but no slough formed. This patient's miserable existence was protracted until April 12, 1853, nearly two years after he entered the hospital, and seven years after he was injured.

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[1] Ibid., 1856, pp. 181–185.

Autopsy.—Remarkable atrophy of the whole muscular system, and of the tissues generally. Pia mater (cranial) and brain-tissue rather watery. On removing the arches of the vertebræ, the whole spinal cord appeared to be large and swollen; in the cervical region the theca was evidently distended by it. The vertebræ and ligaments were not affected. On laying open the theca, there was exhibited a general enlargement of the cervical portion of the cord, which, on transverse section, had an unusual appearance. The columns had a yellowish tint, and were distended by a soft, vascular, translucent growth, parts of which were firmer, and of an opaque-yellow hue. This growth was not defined, but passed insensibly into the degenerated gray substance, which, from the floor of the fourth ventricle to the filum terminale, was pale and swollen, and had much the physical character and consistence of thick boiled starch. This soft starch-like substance, under the microscope, was seen to consist of round, oval, and elongated granular nuclei, imbedded in a slimy blastema. At the filum terminale, where the more normal characters of the gray substance were preserved, these nuclei were scattered amongst the softened tubercles with exudation-cells. The vascular growth in the cervical region consisted of degenerated nerve-tissue, nuclei and nucleated cells, as in the fibro-plastic growths. The opaque part was little else than granular matter and oil-globules. There was no lesion of the membranes of the cord, nor was the continuity of the columns destroyed, though in the cervical region they were spread out, and slightly softened in parts. The nerves arising from the cord in the cervical and lumbar regions, examined microscopically, had the normal structure.

The upper lobes of both lungs contained tubercular masses and scattered tubercles; bronchial tubes dilated; their lining membranes deeply injected and contents purulent. Hepatic tissue congested and fatty. The remaining organs were all healthy.

In this example the spinal meninges were not inflamed (as the autopsy showed), and the symptoms developed were purely those of chronic traumatic myelitis, commencing in the cervical portion of the cord. These symptoms, in general, consisted of a slowly progressive, though somewhat fluctuating, abolition of the functions of the spinal cord. There was progressive sensory and motor paralysis, which, after the lapse of some years, terminated in complete paraplegia. It seems that there was no pain observed until the end drew near, when "complete paralysis of the walls of the chest, as well as of the extremities, and general anæsthesia" had already been established, "yet great pain" was felt "when the body or limbs were roughly handled." This sort of pain, especially when it is associated with general anæsthesia or sensory paralysis of the parts in which it is perceived, is a not uncommon form of hyperæsthesia, and it arose in the case under consideration either from the inflammatory changes that were occurring in the gray substance of the cord, or from the excitation of the sensory filaments in the adjacent spinal nerves that was caused by inflammation of the cord-substance itself, but probably from the former.

The general atrophy of the muscles of the extremities, observed in the progress of this case before the more distinct symptoms of paralysis appeared, is deserving of special note, as bearing upon the theory of progressive muscular atrophy, many examples of which have no doubt had, contrary to the opinion of those who have recorded them, a spinal rather than a muscular origin. The atrophy of the muscles of the right shoulder, whilst those of the forearm still retained some power, elucidates the seat of the paralyzing lesion in some cases of infantile paralysis of the shoulder occurring during dentition. It has been doubted whether the lesions alluded to have a cerebral or a spinal origin; but their occurrence without any cerebral symptoms, the occasional implication of both arms, or of all the extremities, and the actual observation of a limited spot of ochrey discoloration in the cord, as in one case examined by Cruveilhier, concur with the collateral evidence here afforded in proving a spinal origin for this form of paralysis. (Gull.)

Again, the limitation of the paralysis at its commencement to the right arm, and the preponderating affection of the muscles of the shoulder-joint, are points in the clinical history of this case of great interest in another particular. For, taken together with the injury of his right hand, to which the patient attributed his symptoms, they led to an opinion that the case was one of peripheral paralysis. But such an inference was not supported by the history of the case, nor by the post-mortem appearances of the cord. The slight affection of the muscles of deglutition (paralysis), the sense of choking, and the occasional loss of power over the bladder, which appeared early in the case, established a causal relation between the blow on the cervical part of the spine and the inflammatory lesion of the spinal cord-substance, whilst the peripheral-origin theory of the malady was completely refuted by the normal microscopic structure of the nerve-trunks.

There is nothing more fallacious in practical medicine than hastily inferring a negative from negative evidence, as was clearly shown in this case. The absence of pain on percussing the spine, and the very positive statement made by the patient, that his paralytic symptoms had resulted from an injury of his hand, led to the belief that no morbid process of an active kind was at work in the spinal cord; yet it cannot be doubted that the reverse was the fact. Moreover, the least consideration will serve to show that if the vertebral ligaments, and bones, and joints be healthy, no amount of pressure or percussion, made in the usual way during a clinical examination, can much affect the substance of the cord itself, and that we should base no inference upon the negative evidence thus afforded. Oftentimes myelitis, whether acute or chronic, runs its whole course without the development of any pain whatever, excepting cutaneous hyperæsthesia, discernible, it may be, only by a very careful examination.

The impairment of vision, which was observed in this case, although a minor symptom, is deserving of particular notice. It may be associated, from different causes, with spinal lesions. Here it is probably referable to anatomical changes in the cervical portion of the cord itself, inasmuch as experiments on animals have clearly shown that the condition of the eye is at once affected by injuries to the roots of the cervical nerves.

Vomiting, in persistent, recurring attacks, appeared in this case, as an early sign that the cervical portion of the spinal cord was diseased, and was probably dependent upon the origin and connections of the phrenic nerves. In another case seen by Gull, that belonged to the same category, the symptoms set in with an irritating cough; and "I remember," says the same high authority, "an obstinate case of hiccough which, having resisted other treatment, yielded at once to blisters on either side of the cervical portion of the spine, over the origin of the phrenic nerves."[1]

The morbid appearances of the gray matter of the cord were peculiar, and probably depended in part upon degeneration of the normal structure, and in part upon a neoplastic formation of the simplest kind. In the cervical region, where the disease began, the morbid process had proceeded furthest, making an approach to the development of a tumor, but not separated by any line of demarcation from the other parts of the gray matter, which had undergone a similar, only a less advanced, change.

More recently, however, the morbid anatomy of progressive muscular atrophy has been studied with great care by MM. Hayem, Charcot, and Joffroy. In M. Hayem's case, death resulted from paralysis of the diaphragm and pneumonia. The lesions revealed by the post-mortem examination pointed to the existence of chronic inflammation of the gray substance of the cord. MM. Charcot and Joffroy were struck in examining the gray substance of the cervical region in their cases, by the extreme degree of atrophy which the cells of the anterior cornua had undergone; a large proportion of them had disappeared so completely as to leave no trace behind. The posterior cornua were unaffected. M. Charcot states that when the alterations are very well marked, the anterior horn of gray matter, which is the seat of the morbid process or the essential lesion, may become considerably reduced in size, and may present a shrunken appearance in transverse section.

But the symptoms of progressive muscular atrophy, when it arises from concussion of the spinal cord, may come on with great rapidity, as was observed in the following instance, which was also reported by Sir W. Gull:—[2]

A lad, aged 15, received a blow with the fist, between the shoulders, from a boy at play. After a week his head drooped, and from that time the muscles of his upper extremities gradually wasted; the arms dropped and hung useless, the intercostals lost their power, and the breathing was diaphragmatic; the lower two-thirds of the trapezii and the erector spinæ muscles also wasted in the same way.

Fourteen months after the accident, when he tried to stand erect, his head fell forward, and his shoulders were thrown backward to balance it, in the absence of muscular power. He was able to walk, but his gait was vacillating, apparently more from want of muscular power to fix the trunk on the pelvis than from defective power in the legs. He could not sit on a seat without a support to his back. Sphincters unaffected. On testing the electro-contractility of the wasted muscles, by galvanism, they were found to contract in proportion to their mass. No pain attended the progress of the disease; no tenderness of the wasted muscles; no flickering contractions of their fibres.

We now proceed to mention certain *joint-diseases* of spinal origin which must likewise be reckoned among the remote effects of spinal injuries.

(1) M. Charcot has called attention to the *arthropathy* of patients having *locomotor ataxy*.[3] Without any appreciable cause we may see, occurring in one night, the development of a general and often enormous tumefaction of the member, most commonly without any pain whatever, or any febrile movement. At the end of a few days, the general tumefaction disappears, but a more or less considerable swelling of the joint remains, owing to the

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[1] Ibid., p. 185.

[2] Ibid., 1858, pp. 195, 196.

[3] Lectures on the Diseases of the Nervous System, pp. 79–82. Am. ed.

occurrence of hydrarthrosis; and sometimes to the collection of liquid in the periarticular bursæ also. On making a puncture, a transparent, lemon-colored liquid has frequently been withdrawn from such joints. Ataxic arthropathy usually occupies the knees, shoulders, and elbows; it may also affect the hip-joint. This disorder generally shows itself at a determinate epoch of the ataxy, and its appearance coincides in many cases with the setting in of motor incoördination.

(2) MM. Patruban, Remak, and Rosenthal have observed in *progressive muscular atrophy*, joint-diseases which are closely allied by their clinical features to the arthropathies of ataxic patients. This will not appear surprising, if we remember that a primary or secondary irritative lesion of the nerve-cells of the anterior cornua of the spinal gray substance is the starting point of progressive muscular atrophy. (Charcot.)

(3) Sir W. Gull relates the following highly instructive case of rachidian *concussion*, which was followed by incomplete paraplegia, with redness and swelling of the wrists and ankles, as in acute rheumatism; and, after six months, by recovery:—[1]

A medical man, aged 38, inadvertently stepped backward into a hole, a few feet deep, and received a concussion of the spine, on January 22, 1855. After a few days he became partially paraplegic, with weak sphincters; and, at the same time, there came on a diffused redness and swelling of the ankles and wrists. The swelling was not from effusion into the joints, but from œdema of the surrounding tissue. The joints were very painful. The redness and swelling were variable in degree. When most marked, they presented the usual appearances of rheumatism, or rather of gout, for the erythema was brighter, and the œdema more distinct, than in rheumatism. The hands were affected equally with the ankles, though there was no obvious want of muscular power, nor any affection of sensation in the upper extremities; tongue clean; pulse 120; no acid perspiration; urine high-colored, free from sediment, and normal in quantity. The cutaneous nerves generally were hyperæsthetic to a slight touch, but deep pressure gave less inconvenience.

The treatment consisted of good nourishment, wine and brandy freely administered, and opium to allay pain and overcome insomnia. The pulse gradually acquired more power and sank to 80.

The affection of the joints continued in varying degree through March, April, May, and June. From the beginning of April there was an improvement in the power over the legs. The same treatment was continued throughout, without the use of mercurials, local depletion, or counter-irritation. In June, he was able to walk without assistance. During sleep, his hands and feet, wrists and ankles, often became erythematous and swollen. Occasionally, there was formication in the lower extremities. Insomnia was a troublesome symptom from the beginning until the end of the case. In July, he was able to leave the hospital, and to resume his duties as a medical practitioner to some extent.

The disorders, however, which present themselves most frequently as the remote effects of spinal injuries, are chronic spinal meningitis and chronic myelitis. In regard to the symptoms which appear in cases where these two affections coincidently occur, it should be stated that the phenomena which are characteristic of meningeal inflammation will be less and less apparent in proportion as the cord-substance becomes more and more affected by the inflammatory process, and the symptoms of paraplegia, or arrested rachidian functions, will correspondingly predominate. In a case related by Sir W. Gull,[2] in which the cord-substance speedily became inflamed as well as the spinal membranes, "the patient was unable to leave his bed on account of the weakness of his legs," "within thirty-six hours from the commencement of the disease;" and, when admitted to the hospital, "on the ninth day from the commencement of his symptoms," "there was complete loss of motion and sensation. It was also remarkable how entirely the functions of the brain were undisturbed throughout, contrasting strongly in this particular with a large proportion of the recorded cases of acute spinal meningitis." These differences are easily explained by the extent of the injuries or by the other conditions which engender the disorder, and by the patient's temperament, the extent of the disease itself, and the actual presence of disease in the brain or its membranes.

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[1] Guy's Hospital Reports, 1858, pp. 199, 200.

[2] Ibid., 1856, pp. 154, 155.

Treatment.—In all these cases, uninterrupted rest in bed is a remedial measure of great importance. Ergot should be perseveringly administered in full doses, with a view to control the congestion of the spinal cord and its membranes which is present in almost all of them. Potassium iodide and the corrosive chloride of mercury should be given, together or separately, with a view to dispose of the inflammatory products. In cases tainted with syphilis, these remedies will often prove singularly useful, as I know from experience. Counter-irritation should be made over the spinal column with dry-cupping, setons, or the actual cautery. The latter especially has often been found to do much good in such cases. Progressive muscular atrophy requires the employment of the primary galvanic current to the spinal cord itself, from above downward, and of the faradic current to each of the wasted muscles.[1]

RAILWAY-INJURIES OF THE SPINE are, as a group, characterized by the coincident occurrence of sprains, wrenches, or twists of the vertebral column, stretching of the spinal membranes—particularly the theca—corresponding thereto, and profound concussion of the rachidian substance. Hence, in such cases there may coincidently appear inflammation of the vertebral joints, inflammation of the spinal membranes, and inflammation of the rachidian substance. Moreover, in these cases there is always peculiar difficulty experienced in determining the full extent of the damage—difficulty which is often increased very much by the absence of all external evidence of physical injury, by the obscurity and insidious character of the early symptoms, by the slowly progressive development of the secondary organic lesions, as well as of the functional derangements produced by them, and by the uncertainty which surrounds the ultimate issue. They therefore constitute a class of injuries which often severely tax the surgeon's diagnostic skill and therapeutic resources.

The nature and peculiarities of railway-injuries of the spine can be most clearly shown by presenting an example:—

Mrs. J. C. F., aged 31, and married, consulted me on March 11, 1881, in regard to the effects of injuries which she had received in a railway-collision, on Christmas-eve, something more than two and one-half months before. While seated in the rear portion of a railway car, she suddenly saw that a collision was inevitable, and sprang to her feet, and was therefore standing when the cars collided. She was terribly shaken up and wrenched in the loins, as well as thrown about, and felt stunned, cold, and faint. There was so much depression from "shock" that a druggist administered ammonia to excite reaction. She was in perfect health when the accident occurred, but has not seen a well moment since that time. Next day, she felt lame and sore "all over," and had severe pain in the lumbar region, which was increased by motion, and pain in the left hip. The pain in the loins and left hip continuing eight days after the accident, she sought for relief at the Woman's Dispensary, when tincture of iodine appears to have been applied to the painful hip, but without doing any good whatever. At this time she had a miscarriage, being, as she thinks, about two months advanced in pregnancy. March 11. She says that she has not been free from the pains above mentioned since the accident; has now much distress in the cervical and dorsal, as well as in the lumbar portion of the spine; the pains extend from the left loin and hip downward into the left thigh and knee; has also much pain extending from the spine into the left arm, and numbness in the parts supplied by the ulnar nerve (little finger and adjacent side of ring finger); has lost much flesh; is very weak and nervous, and has been so ever since the accident; often has cardiac palpitations so marked that she is afraid to go into the street alone; pulse frequent (about 100), and rather weak; countenance anæmic, and expressive of great suffering; tongue clean; bowels regular; appetite and digestion good, but her food does not seem to benefit her; she suffers much from insomnia, for the pains in her spine, left hip, and left extremities, both lower and upper, keep her awake; the lumbar part of the spine, especially the left side thereof, exhibits tenderness under pressure. I prescribed the bromides of potassium, sodium, and iron, in full doses, with rest as nearly absolute as possible, and counter-irritation to be applied over the whole spinal column; and I hoped that, as the inflammation of the wrenched vertebral articulations should subside under this treatment, the symptoms of meningo-rachidian irritation would likewise disappear.

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[1] See also what has already been said concerning the treatment of the acute and subacute forms of traumatic spinal meningitis and myelitis.

July 21. She is no better; is much emaciated (weighing but 103 lbs., while her usual weight is 119 lbs.); is pallid, and looks wan, wearied and prematurely old; has much distress in the head, with a sore feeling in the scalp, and rapid falling of the hair; pains in the spine and left hip continue severe, and involve the whole of the left upper extremity, as well as the whole of the left lower extremity; pains sometimes shoot down into her left leg and foot; has no pain in the right extremities; suffers great distress at the bottom of her back, across the sacrum (sacrodynia), and when her back is worse her distress in the head is more severe; she also has formication, a "pins and needles" feeling, and a sensation of numbness or as if the parts were asleep, in all of her left side, and in her left hip, but especially in the left foot and leg; has likewise a "pins and needles" feeling in the left hand and arm, but not as much as in the left lower extremity; has a constricted or "tight-belt" feeling which extends around her body; the muscles of her left leg and thigh often feel stiff; her pains and abnormal sensations are always made worse by getting tired; during the last two months, exercise, or a sense of fatigue, always brings on nausea, and sometimes vomiting; feels sick at the stomach this morning in consequence of walking to my office; lies in bed on her left side, because she gets more ease in that position; has often to get up at night and rub the affected parts on account of the "pins and needles" feelings, and sensations of numbness; is very restless at night, and scarcely ever sleeps more than two hours at a time; menstruation irregular and deficient;" she also has much thirst and "inward fever;" pulse about 100, and feeble; tongue clear, bowels soluble. Potassium iodide, in ten grain doses, three times a day, was ordered as a remedy against the spinal meningitis and myelitis which were obviously now present, with syrup of the hypophosphites of lime and sodium as a tonic; counter-irritation over the left hip and the whole length of the spinal column, to be continued, with rest in bed; but unfortunately her circumstances in life were not such that the last-named remedial measure could be carried out as thoroughly as was desired.

October 2. Her case became complicated with an attack of malarial fever, which was promptly subdued by the administration of quinine.

March 21, 1882. She is somewhat better, but her eyesight is impaired; says that after resting in bed for a time, she always gets better; but, as soon as she begins to go around again, especially if she tries to work, she again gets worse. In addition to potassium iodide, syrup of the iodide of iron, gtt. xv., three times a day, was prescribed.

June 12. I was called, and found her suffering very much from coccygodynia; the sacro-coccygeal articulation was inflamed, and so much damaged that the coccyx was quite movable, as well as bent forward at nearly a right angle; her general symptoms, however, were upon the whole rather better.

June 15. Professor Wm. A. Hammond saw her in consultation. Her weight is now 99½ lbs.; it used to be 119 lbs.; the headache continues, and her eyesight is very much impaired; she has difficulty in holding her urine, which is normal in appearance; makes it too often, and has to run in order to avoid wetting herself (vesical hyperæsthesia); has pain in the lumbar, sacral, and coccygeal regions all the time, and it is always aggravated by exertion. There is much tenderness under pressure along the left side of the dorsal and lumbar vertebræ, and over the whole of the sacrum; the head of the coccyx is displaced forward, and crepitus can be felt in the sacro-coccygeal joint; tenderness about the lower end of sacrum and coccyx much complained of by the patient; besides pain, etc., she says she has a "stiff feeling" in the muscles of the left thigh and leg, which is worse at some times than at others; says she also feels constricted around her bowels, as if her clothes were too tight, or as if a belt were tightly drawn and buckled around her bowels, and has had this feeling for a long time. The æsthesiometer showed that cutaneous sensibility in the left thigh was less than normal. In addition to syrup. ferri iodid., which she was now taking, fluid extract of ergot in full doses was prescribed, with strong counter-irritation over the sacrum.

December 6. Upon the whole she is much better. The sacro-coccygeal pain is greatly lessened, and anchylosis of the joint appears to have occurred, with the coccyx bent forward and somewhat to the left at a right angle. Her eyesight, however, is very much impaired. The vesical hyperæsthesia, too, has returned, and gives much trouble, for she has to make water every few minutes. Ordered extract of belladonna gr. $\frac{1}{4}$, ergotine, gr. iiss., to be taken in pilular form three times a day; in four days the vesical reflex became normal. Also advised the belladonna and ergotine to be taken for a fortnight longer, and to be followed by potassium iodide.

The internal remedies which did this patient most good were ergot, belladonna, and potassium iodide; and the benefit derived from their administration was very evident.

The spinal lesions in this case were mostly unilateral; and, as a rule, involved the left half of the column only. The spinal articulations which became inflamed were certain of the lumbar, as well as the lumbo-sacral, and the sacro-coccygeal. The pain felt in the dorsal and cervical parts of the spinal column, and in the left arm, forearm, and hand, was due entirely to spinal meningitis. The pain in the head and the impairment of vision, which came on afterwards, were probably due to extension of the inflammatory process from the spinal to the cerebral membranes. The pain in the lumbar vertebræ, sacrum, and left lower extremity, was caused in part by spinal meningitis, and in part by inflammation of the vertebral joints. The sensations of numbness, or as if the limb were asleep, of formication, of "pins and needles," of constriction around the body as if it were tightly belted, and the cutaneous anæsthesia, arose from myelitis. The vesical hyperæsthesia probably arose from rachidian hyperæmia and irritation, whereby the urinary bladder's reflex centre became unduly excited. At least, such was my diagnosis; and, on administering ergot to subdue the rachidian hyperæmia, and belladonna to allay the vesical reflex excitation, relief was promptly obtained. The nausea and vomiting which at one time were brought on by any slight muscular effort, also indicated that the cervical portion of the spinal cord-substance was inflamed. This woman, almost two years after the accident, although much improved in health, is not yet well again, for she is still suffering from inflammation of the spinal cord and its membranes. Moreover, there is much doubt as to whether she ever will entirely recover.

The phenomena which present themselves in cases where spinal injuries, without fracture, are caused by railway-collisions, result, as already intimated, from the severe wrenches and twists which the vertebral joints have sustained, or from the violent stretching and hemorrhagic infiltration to which the spinal membranes have been subjected, or from the more or less profound concussion, and perhaps contusion, of the substance of the spinal cord itself, or from the combined influence of all these lesions. We shall not be surprised to find that such grave consequences may be engendered by railway-collisions, if we reflect for a moment upon the nature of these accidents. It must, I think, be evident to all that, in no ordinary accidents can the shock, both physical and mental, be nearly as great as in those which occur in the collisions of railway-cars and engines. The swiftness of the movement, and the extraordinary momentum of the persons injured, as well as of the vehicle which carries them, the suddenness of its arrest, and the helplessness of the victims, are all circumstances which of necessity greatly augment the severity of the injuries sustained by the spinal column and cerebro-spinal axis. But perhaps there is one circumstance which more than any other gives a peculiar character to railway-collisions, namely, the thrill or jar, the "*ébranlement*" of French writers, the sharp vibrations, in fact, which are transmitted to everything that is subjected to the force of such collisions. It is this vibratory shock or jar, which by some is compared to an electric shock, by others to setting the teeth on edge (Erichsen), that causes railway carriages to be shattered into splinters on colliding, and produces the sharp tremulous movement which runs through every structural fibre of the occupants, whereby profound concussion or contusion of their spinal cords is oftentimes effected. Moreover, the body of the passenger is simultaneously pitched about or hurled to and fro, not unfrequently five or six times, without there being any power of resistance or of self-preservation, and thus the vertebral articulations are often severely wrenched, as well as the spinal membranes severely stretched and irritated.

Those injured by railway-collisions may sustain dislocations and fractures of the vertebræ, lacerations of the spinal meninges with intra-vertebral hemorrhage, and lacerations of the substance of the spinal cord with intra-rachidian hemorrhage. It is not, however, my purpose to devote now any time to the discussion of these lesions, for they differ in no wise from those produced by falls and blows, which have already been fully considered in the foregoing pages. Likewise, acute inflammations of the spinal membranes and spinal cord may arise from the injuries occasioned by railway-collisions. These disorders have also been so fully discussed above, that it is now unnecessary to take them up again. We are at present chiefly concerned with the *remote effects* of the spinal injuries which result from railway-collisions, such, for example, as chronic inflammation of the vertebral joints, chronic spinal meningitis, and chronic myelitis, together with the structural changes, and functional disturbances, or phenomena, by which these affections are severally attended. And, inasmuch as chronic vertebral arthritis with caries and necrosis, chronic spinal meningitis, and chronic myelitis, when they present themselves as the remote effects of spinal injuries caused by railway-collisions, differ in no essential particular, with regard to anatomical changes, functional disturbances or symptoms, and therapeutic indications, from the corresponding affections of the spine which are not unfrequently produced by blows on the back and various common accidents, the discussion of which has just been ended, I shall not occupy much space in any further discussion of them.

In respect to the symptoms by which the remote effects of spinal injuries caused by railway-collisions are characterized, they will be found to vary according as the inflammatory lesions of the vertebral articulations, of the spinal membranes, or of the spinal cord-substance, may predominate. For instance, in cases where myelitis constitutes the principal secondary lesion or disorder, cutaneous anæsthesia and complete paraplegia, with alkaline urine, etc., often combined with hyperæsthesia, will probably be observed at an early period; while in others, where meningeal inflammation constitutes the main affection, there will be marked cutaneous hyperæsthesia with severe peripheral pains, as well as intense pain in the spinal column itself, combined perhaps with tetanic spasms of the posterior cervical, abdominal, and other muscles, but without any paralysis whatever of the voluntary muscular apparatus.

As Mr. Erichsen well remarks, one of the most remarkable phenomena of this class of cases is, that, at the time of the accident, the victim is often quite unconscious that he has received any serious damage. He feels that he has been violently jolted, and shaken; he likewise feels, perhaps, somewhat giddy and confused, but he finds no bones broken, merely some superficial cuts or bruises, and possibly even no external evidence whatever of injury. He congratulates himself upon his escape from the imminent peril to which he has been exposed, and gives valuable aid to his less fortunate fellow-passengers for several hours. But, when he reaches his home, the effects of the injury which he has sustained begin to manifest themselves. He bursts perhaps into tears, and becomes unusually talkative, as well as excited. He cannot sleep, or, if he does, he suddenly wakes with a vague sense of alarm. Next day he complains of feeling shaken or bruised all over, or as if he had been beaten, or had violently strained himself by exertion of an unusual kind. This stiff, strained, and sore feeling chiefly affects the muscles of the loins and neck, but sometimes involves also those of the thighs and shoulders. After a time, which varies in different cases from a day or two to a week or more, the victim finds that he is unfit for exertion and unable to attend to business. He now lays up, and perhaps for the first time seeks surgical assistance. (Erichsen.) His countenance becomes pallid, wrinkled, and acquires a care-worn or anxious expression; and he generally looks much older than he really is, or than he did before the accident. Some time subsequently, and possibly long afterward, the symptoms mentioned above, of spinal meningitis and myelitis, present themselves; and these grave disorders run their destructive course, unless they are fortunately arrested by timely treatment.

Pathological Anatomy.—As far as I know, there is but one case on record in which, death having ensued as a remote consequence of spinal lesions arising from a railway-collision, the morbid state of the spinal cord and its membranes has been accurately determined by a thorough post-mortem examination. The history of this highly important case is briefly as follows:—

A man, aged 52, and of active business habits, was the subject of a railway-collision. Immediately after it he walked from the train to the station near by. He received no contusions, nor wounds, nor any external sign of injury; but he did complain of pain in his back. He strove hard to keep up, and at his business, and did so for a short time after the accident, although with much distress. Numbness and want of power in the muscles of his lower limbs appeared, and gradually but steadily increased; thus he soon became disabled. His gait became unsteady, and like that of a semi-intoxicated person. There was also extreme sensitiveness to external impressions, so that a shock against a table or chair gave him great distress. The paralytic symptoms came on in less than one year after the accident. In the latter part of his illness, some weakness of his upper extremities became apparent, so that, when he was off his guard, a cup or a glass would slip from his fingers. He could barely walk with the aid of two sticks; and at last he was confined to bed. His voice became thick, and his articulation imperfect. There was no paralysis of the bladder until about two years after the accident, when his urine became pale and alkaline, with muco-purulent deposit. He died three and one-half years after the accident.[1]

Dr. J. Lockhart Clarke carefully examined the spinal cord and membranes, which were obtained at the autopsy of this case, and reported upon them as follows:—

"I found that the membranes at some parts were thickened, and adherent at others, to the surface of the white columns. In the cord itself, one of the most striking changes consisted in a diminution of the antero-posterior diameter, which, in many places, was not more than equal to half the transverse. This was particularly the case in the upper portion of the cervical enlargement, where the cord was consequently much flattened from behind forward. On making sections, I was surprised to find that of all the

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[1] Erichsen, On Concussion of the Spine, etc., pp. 178, 179. 1882.

white columns, the *posterior* were exclusively the seat of disease. These columns were darker, browner, denser, and more opaque than the antero-lateral; and when they were examined, both transversely and longitudinally, in their preparations under the microscope, this appearance was found to be due to a multitude of compound granular corpuscles, and isolated granules, and to an exuberance of wavy fibrous tissue disposed in a longitudinal direction. It was very evident that many of the nerve-fibres had been replaced by this tissue, and that at certain spots or tracts, which were more transparent than others, especially along the sides of the posterior median fissures, they had wholly disappeared. Corpora amylacea also were thickly interspersed through the same columns, particularly near the central line. The extremities of the posterior horns contained an abundance of isolated granules like those in the columns, and in some sections the transverse commissure was somewhat damaged by disintegration. The anterior cornua were decidedly smaller than natural, and altered in shape, but no change in structure was observed."[1] Dr. Clarke remarked that the alterations in appearance presented by the cord, in this instance, bore a striking resemblance, in the limitation of the principal lesions to the posterior columns, to what is met with in locomotor ataxy.

The post-mortem examination of this case also revealed traces of chronic inflammation in the cranial arachnoid membrane, and in the cortical substance of the brain.

From the foregoing account of this case, it appears that the injuries caused by the railway-collision eventuated in chronic hyperæmia and chronic inflammation of the spinal arachnoid membrane and spinal cord-substance, especially the posterior columns thereof, which slowly spread upward until finally the morbid process involved the encephalic arachnoid membrane, and the cortical substance of the brain. Moreover, there is good reason to believe that when the inflammatory process attacks other portions of the spinal cord in cases belonging to this category, it is capable of producing progressive muscular atrophy, and other important consequences, which have been mentioned above.

Brief mention must here be made of some rather important complications which present themselves with great frequency in cases where spinal injuries have been produced by railway-collisions without luxation or fracture.

(1) *Impairment of Vision.*—One of the most frequent and troublesome among the remote effects arising from injuries of the spine, especially those received in railway-collisions, is diminution of the eye-sight. As a rule, this complication is met with only in cases where there is traumatic inflammation of the spinal cord and its membranes, which pursues a chronic course. For instance, it presented itself some considerable time after the accident in the case of Mrs. J. C. F., which has been related above. On examination, I found her eyeballs sunken, flattened, watery, and dull in appearance, and looking like the eyeballs of a much older person. The pupils were contracted to one-half the normal size, and were also sluggish. She complained that her eye-sight had become weak and dim. There was no diplopia, but objects appeared to her to be enveloped by mist or fog. At one time, she had black spots floating in the field of vision. The veins of the eyeballs were dark-purple, and distended with blood. Her vision was much better on some days than on others; for example, it was much better on bright than on dull days. She could not see except in a good light.

This subject has been carefully investigated by Mr. Wharton Jones and Dr. Clifford Allbutt. The former states that the pupils are usually half-closed, the eyes sunken, dull, and watery, and the veins of the eyeball congested, which abnormal appearances were all noted in the case recorded by myself. He also states that the movements of the pupils are sometimes normal, sometimes sluggish, and sometimes abnormally active. They are sluggish in cases of asthenopia, but abnormally active in cases where there is intra-ocular hyperæmia or inflammation.[1]

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[1] Transactions of the Pathological Society of London, vol. xvii. p. 21.

The ophthalmoscopical appearances presented by cases of spinal disease or injury have been described by Dr. Allbutt, as well as by Mr. Wharton Jones. Dr. Allbutt finds that they may all be classed under two heads:—

> "1. Simple or primary atrophy of the optic nerve, sometimes accompanied at first by that slight hyperæmia and inactive proliferation which make up the state I have called chronic neuritis. This sort of change I have never found as a result of spinal injuries, but I have often met with it in chronic degeneration of the cord and in locomotor ataxy. 2. A somewhat characteristic hyperæmic change, which I have not seen in chronic degeneration, nor in locomotor ataxy, but in cases of injury to the spine only. The retinal arteries do not dilate, but become indistinguishable; while the veins begin to swell, and become somewhat dark and tortuous. The disk then becomes uniformly reddened, and its borders are lost, the redness or pinkness commencing with increased, fine vascularity at the inner border, which then invades the white centre and the rest, so that the disk is obscured, or its situation known only by the convergence of the vessels. In many cases, rather than redness, I have observed a delicate pink—pink which sometimes passes into a daffodil color. In one case in particular—a railway accident—which I examined in consultation with my friend and colleague, Mr. Teale, this daffodil color of the whole field was very curious; no disk was to be distinguished, but the dark vessels stood out in beautiful relief. The other eye presented the common appearances of hyperæmia and serous effusion, with slight swelling. It is to be remarked that this state is generally or always of long duration; it passes very slowly up to its full development, and then shows a disposition to end in resolution rather than in atrophy. In those cases which I have been able to watch diligently for many months, the pinkness seems slowly to have receded, leaving an indistinct but not very abnormal disk behind. Sometimes the sight suffers a good deal in these cases, sometimes but little or scarcely at all. I have never seen true optic neuritis, with active proliferation, as a sequel of spinal disease."[2]

Dr. Allbutt states that in thirteen cases of chronic spinal disease following accidents, he found disturbance of the optic disk and its neighborhood in eight instances, and that the disturbance of the eye "is seen to follow disturbance of the spine with sufficient frequency and uniformity to establish the probability of a causal relation between the two events." But, in the more severe forms of spinal injury, those, for example, which prove fatal in a few weeks, these evidences of ophthalmic disease are not met with; for, in seventeen cases of this sort, Dr. Allbutt found no evidence of ophthalmic disease in any instance.

To what should the impairment of vision in question be ascribed? The same eminent authority holds "that hyperæmia of the back of the eye, following injury to the spine, is probably dependent upon a greater or less extension of the meningeal irritation up to the base of the brain. Now, have we any reason to suppose that spinal meningitis does creep up into the encephalon? We have: For, setting aside the curious head-symptoms such patients often present, here the actual demonstration of autopsy comes to our aid. It is tolerably well known to careful pathologists that encephalic meningitis is a very common accompaniment of spinal meningitis." Moreover, in a number of instances presented in the foregoing pages, the post-mortem examination revealed the fact that inflammation of the spinal membranes had extended upward until it likewise involved the encephalic membranes. I have no doubt that the ophthalmic lesions above mentioned are solely due to the creeping upward of a chronic meningitis which originally is spinal, but in the end becomes cerebral also.

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[1] On Failure of Sight after Railway and other Injuries, p. 44.

[2] Lancet, 1870, vol. i. pp. 76, 77.

(2) *Impotency.*—Mr. Erichsen states that *priapism* does not occur in cases of spinal concussion resulting from railway-collisions, and that, as a rule, the genitals are quite flaccid in such cases.[1] This statement, however, does not hold good in those concussions of the spinal cord which are attended with contusions of the rachidian substance, or with intra-rachidian extravasations of blood; for there was well-marked priapism in several instances of this sort which have been mentioned in the preceding pages.

Mr. Erichsen likewise states that *sexual desire* and *sexual power* are usually greatly impaired, and often entirely and permanently lost, in consequence of spinal injuries arising from railway-collisions, and Mr. Humphry has seen a case of complete impotence consequent on a jar to the spine thus caused.[2] This, however, is not invariably the case; for the wife of one of Mr. Erichsen's patients miscarried twice during the year succeeding her husband's injuries.[3] There is, however, no doubt, I think, that the spinal injuries produced by railway-collisions usually inhibit for a time, and often completely and permanently destroy, the sexual reflex centre in the spinal cord. In this manner, such injuries frequently give rise to impotency.

(3) *Sacrodynia.*—The group of symptoms arising from spinal injuries received in railway-collisions, to which Mr. Erichsen with much propriety has given the name of *sacrodynia*, consists of the following: Soon, but not of necessity at once, after the accident, the patient feels a diffused pain over the entire sacral and sacro-lumbar regions. It is usually most intense over the sacrum, and especially over the sacro-iliac synchondrosis. It is, however, not confined to this part; for it extends upward as high as the fourth or third lumbar vertebra, and laterally, perhaps, almost to the trochanters. But the sacrum is the focus of its greatest intensity. When the sacro-iliac junction also is the seat of suffering, it is the left that is affected in a large majority of instances. Over the whole of this region there is tenderness under pressure, and the pain is greatly increased by movements of all kinds. There is no nocturnal exacerbation. There is no external sign of injury in the way of swelling, heat, or discoloration. The patient cannot stand erect without increasing the pain; hence, a tendency to stoop slightly forward, and perhaps to incline to one side, is exhibited. Advancing the lower extremities greatly increases the pain; the patient, therefore, walks with difficulty, takes short steps, leans on a stick, and, when one side is more painful than the other, drags the leg on that side. As already stated, the left is much more frequently the painful side than the right, and hence it is that the left leg is so frequently "dragged" in these cases. The greater frequency and the greater severity of sacrodynia on the left side, than on the right, and the consequent dragging of the left leg, are very notable circumstances. They occur in at least three-fourths of all the cases. My patient, whose case has been related above with some particularity, suffered dreadfully in this way. The great preponderance of left-sided cases of sacrodynia, is probably to be explained by the fact that most people are right-handed, and that in consequence thereof they instinctively put forth their right hands for self-protection when they are pitched about the cars in railway-collisions, and at the same time correspondingly advance the right side of their bodies, which of course places their left buttocks and the left side of their sacral bones in a position to bear the brunt of blows received from behind. At all events, I believe this to be the true explanation of the left-sided sacrodynia with which my patient was afflicted. In her case, too, there was so much traumatic inflammation of the sacral ligaments, that the sacro-coccygeal articulation was destroyed by it, and anchylosis of that joint with the coccyx in an abnormal position ensued.

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[1] Op. cit., p. 64.

[2] Holmes's System of Surgery, vol. v. p. 161, foot note.

[3] Op. cit., p. 172.

The symptoms of sacrodynia often continue for a long time. When once they have fairly set in, they will last for many months, and not unfrequently for a year or two. Moreover, the pain does not follow the anatomical course of any nerve, and, therefore, it cannot be classified with the neuralgias. It appears to arise directly from bruising and spraining of the ligamentous structures. The sacro-vertebral, the ilio-lumbar, the sacro-iliac, and the sacro-ischiatic ligaments may all be more or less strained in the bumps, twists, and wrenches to which the pelvis and lower part of the spine are subjected in the accidents under consideration. And, according as the violence falls more or less directly on one or other of these ligaments, so the patient will suffer more or less in the part where it is situated. (Erichsen.) The long continuance of pain in cases of sacrodynia is exactly what we find in cases where the ligaments are strained in other parts of the body.

(4) *Vomiting.*—It will be remembered by some that about twenty-five years ago Sir W. Gull, in Guy's Hospital Reports, called attention to vomiting as a symptom or effect of hyperæmia or inflammatory irritation of the rachidian substance in the cervical region, and recorded an example in which the existence of myelitis in the cervical region (caused by a blow on the neck) was proved by post-mortem examination. This case I have used above to illustrate the remote effects of spinal injuries. It will likewise be remembered that any slight muscular effort on the part of my own patient who suffered from railway-injury of the spine, and whose case I have so often referred to, always produced nausea, and sometimes caused vomiting, and that these symptoms of cervical myelitis lasted for several months. Mr. Erichsen,[1] too, relates a very instructive case in which concussion of the spinal cord caused by a blow on the nape of the neck received in a railway-collision, and the rachidian inflammation which ensued, were attended by vomiting as a prominent and a very persistent symptom. It is obvious that medication for the relief of this symptom, in such cases, should be directed towards the removal of its cause, namely, the rachidian hyperæmia and irritation in the cervical region, upon which its existence depends.

Treatment.—Inasmuch as the spinal injuries arising from railway-collisions may be followed by inflammation of the vertebral articulations, inflammation of the spinal membranes—but particularly of the spinal arachnoid and pia mater—and inflammation of the rachidian substance, the first step consists in making, as far as practicable, a differential diagnosis. Almost always, in such cases, spinal meningitis and myelitis will be found creeping up the cord together into the cranium; and, not unfrequently, all three disorders will simultaneously present themselves. The principles upon which the treatment of each of these inflammatory affections of the spine, whether acute or chronic, should be conducted, have already been laid down, and the several remedial measures which experience has shown to be the most useful in such cases, have already been mentioned; it does not seem necessary to restate them here. One thing, however, I will say, namely: The importance of rest in bed, in these cases, cannot be overestimated. Furthermore, insomnia occurring *per se*, that is, without pain, should be overcome by administering the bromides or chloral hydrate rather than opium or morphia; but pains in the spinal membranes, ligaments, or joints must be subdued by exhibiting the last-named drugs. When the morbid process in the rachidian substance has reached the stage of atrophy, the primary galvanic current passed downward through the cord may prove very useful. But whatever the treatment may be, no speedy benefit can, as a rule, be expected.

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[1] Op. cit., pp. 216–219.

[On page 785 reference is made to the statistics of spinal trephining or resection collected by the Editor. To the 41 cases there mentioned, two additional examples of the operation have recently been added by Prof. Stemen, of Indiana, so that the figures now stand as follows:—

Whole number of cases	43
Patients died	31 or 72.1 per cent.
Patients not benefited	4 “ 9.3 “ “
Patients relieved[1]	4 “ 9.3 “ “
Result unknown	4 “ 9.3 “ “

The following table includes the 43 cases referred to:—

Table of Cases of Resection of the Spinal Column for Injury.

No.	Result.	Operator's name.	Reference.
1	Died	Cline	Chelius's Surgery, ed. by South, vol. i. p. 590.
2	“	Wickham	Lancet, 1827.
3	“	Oldknow	Hutchison, Am. Med. Times, 1861.
4	“	Tyrrell	Malgaigne, Fract. et Luxations, tome i. p. 425.
5	“	Id.	Ibid.
6	“	Barton	Malgaigne (Packard's translation), p. 343.
7	“	Boyer	Heyfelder, Traité des Résections (trad. par Boeckel), p. 244.
8	“	Rogers	Am. Journ. Med. Sciences, O. S., vol. xvi.
9	“	Attenburrow	Chelius and Heyfelder, op. cit.
10	“	Laugier	Malgaigne, op. cit.
11	“	Holscher	Brown-Séquard, Diseases of the Central Nervous System, p. 256.
12	Relieved	A. G. Smith	N. A. Med. and Surg. Journal, vol. viii. p. 94.
13	Died	Mayer	Heyfelder, op. cit.
14	“	South	Notes to Chelius's Surgery, vol. i. p. 591, etc.
15	“	Blackman	Hutchison, loc. cit.
16	Not known	Edwards	Brit. and Foreign Med. Review, 1838.
17	“	Blair	Ballingall, apud Hutchison, loc. cit.
18	“	Goldsmith	Gross, System of Surgery, 2d ed., vol. i.
19	Died	Stephen Smith	Hutchison, loc. cit.
20	“	Hutchison	Ibid.
21	“	Jones	Brown-Séquard, op. cit., p. 255.
22	“	Potter	Hurd, N. Y. Journ. of Med., 1845.
23	“	Id.	Am. Journ. Med. Sciences, N. S., vol. xlv.
24	Not benefited	Id.	Ibid.
25	Died	McDonnell	Ibid., vol. l.
26	Relieved	Gordon	Med.-Chir. Trans., vol xlix. p. 21.
27	Died	Tillaux	Brit. and For. Med.-Chirurgical Review, 1866.
28	“	Willett	Med. Times and Gazette, Feb. 2, 1867, and St. Barthol. Hosp. Rep., vol. ii. p. 242.
29	Not known	H. J. Tyrrell	Dub. Quart. Journ. Med. Sci., Aug. 1866.
30	Died	Maunder	Med. Times and Gazette, Feb. 23, 1867.
31	Not benefited	Eve	Am. Journ. Med. Sci., N. S., vol. lvi.
32	Died	Cheever	Boston City Hosp. Reports, p. 577, 1870.
33	“	Id.	Ibid., p. 580.
34	“	....	St. Barth. Hosp. Reports, vol. vi.
35	“	Nunneley	Med. Times and Gaz., Aug. 7, 1869.
36	“	Id.	Ibid.
37	“	Id.	Ibid.
38	Relieved	Id.	Ibid.
39	Died	Willard	Am. Journ. Med. Sci., N. S., vol. lxiii.
40	Relieved	Stemen	Fort Wayne Journ. of the Med. Sciences, April, 1883.
41	Not benefited	Id.	Ibid.
42	Died	Id.	Ibid., Oct. 1883.
43	Not benefited	Lucke	Revue des Sciences Médicales, Avril, 1880.]

[[1] There is no recorded instance of complete recovery after spinal resection.]

MALFORMATIONS AND DISEASES OF THE SPINE.

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SPINA BIFIDA.

THE term "spina bifida" is applied essentially to a hernia of the membranes of the cord through a congenital fissure in some portion of the bones forming the spinal column.

PATHOLOGICAL ANATOMY.—Speaking generally, the congenital deficiency that leads to spina bifida is in the posterior segments of the column, and is at the expense of the laminæ and spinous processes. Through the bony gap the spinal membranes protrude, distended by an abnormal amount of cerebro-spinal fluid. Often the cord itself, or some part of it, takes a share in the protrusion. The spina bifida, therefore, appears as a tumor of variable size, situated in the middle line, covered with normal or more or less modified integuments, and presenting the essential features of a simple cyst.

CAUSES.—As to the *causes* of spina bifida nothing definite can be said, and the etiology of the affection must for the present be hidden under the general term, "arrest of development." A vast number of theories have been propounded upon the subject, supported for the most part by a minimum of facts; and it must be confessed, that in spite of long argument and a multitude of opinions, little real addition has been made to our knowledge of the causes of this and like deformities. Perhaps the most essential question that requires to be answered is this: Which is the primary defect, the arrest of development in the bones, or the dropsy of the membranes? Does the deficiency in the bony canal encourage a protrusion of the membranes, or has the protrusion prevented the proper formation of the osseous canal? Those who are interested in this discussion will find the matter fully argued out by Follin and Duplay, in their *Traité de Pathologie Externe.*

SITE.—The common situation for spina bifida is in the lumbo-sacral region. Indeed, it may be said that the deformity is rare elsewhere. Next in frequency to the lumbo-sacral region comes the upper cervical region, and then the rest of the cervical spine, while the least frequent spot for a spina bifida is the mid-dorsal region.

NUMBER.—The spina bifida is usually single. In rare cases, however, there may be two examples of the deformity in the same person. Thus there may be a spina bifida in the lumbo-sacral region, and another in the neck. Bryant figures a case where there was one tumor in the lumbar region and another in the sacral.[1]

Condition of the Bone.—An examination of the vertebra at the site of the spina bifida will show that the spinous process is absent, and that the corresponding laminæ are also entirely absent, or more or less defective. The remainder of the bone is usually perfect and well developed. The osseous defect is rarely limited to one vertebra. It usually involves two or three, or more. In some few instances, in monsters, all the vertebræ have been found involved —a condition not compatible with existence. Follin and Duplay[2] cite some instances where the defect in the bone extended as a cleft through the entire body of the affected vertebra; and Bryant[3] has reported the case of a woman, aged 25, who died from accident, and who presented an *anterior* spina bifida. Dr. John Ogle, has recorded a remarkable case of spina bifida opposite the upper lumbar vertebræ, where the body of the second lumbar vertebra was deficient, and was so pushed backward that the first and third vertebræ came almost in contact. The defect was associated with a very marked and abrupt curvature of the spine backwards at the seat of the spina bifida.[4]

The Tumor.—The tumor varies greatly in size, and may range from a protrusion the size of a walnut to a mass larger than an infant's head. Broca exhibited a case in an adult man, where the circumference of the tumor was 45 centimetres (17.5 inches). The usual size of the tumor at birth is from that of a bantam's egg to that of a small orange. According to Follin and Duplay, there may be no tumor at all, but merely a cordiform or oval patch on the skin, associated with no elevation of any kind. It is asserted that this condition may occur with division of many vertebræ. The tumor is usually round, or oval, with its greatest axis longitudinal, and is of regular outline. The wall of the sac is thin and ultimately adherent to the skin or its representative. In cases that have existed for some years, the sac wall may become greatly thickened, and may present some calcareous change. In certain large tumors the outline of the mass may be bossy and irregular, probably from unequal resistance of the envelopes. The tumor may be sessile, but it is usually pedunculated. The size of the pedicle depends upon the size of the hole in the vertebral canal. In process of time the pedicle tends to become lengthened, a condition that depends much upon the weight of the tumor, the size of the opening into the spinal canal, and the maintenance of the vertical position.[5] The skin covering the spina bifida is rarely normal. It is usually thinned and deficient, often shining and purple, and not unfrequently inflamed. In other cases the skin may be hard and coriaceous; it may be hairy, or in a condition of ichthyosis. Sometimes it is found to be hypertrophied, although more commonly it is deficient, and may be entirely absent. In the latter case, the spinal dura mater is exposed as a bluish-red and vascular membrane. The defective skin, moreover, may be represented by a scanty fibrous material, not unlike cicatricial tissue, or the integuments may be hypertrophied at the periphery of the tumor and atrophied at its centre. The deficiency in the integuments may depend upon congenital defect in those parts, or may be due to a wasting of the coverings of the tumor, consequent upon increasing pressure from within. In many cases the coverings of the spina bifida are curiously inflamed and appear very vascular and rugose; or they may be sloughing, or the seat of more or less considerable ulceration. A nævoid condition of the skin is by no means uncommon, either over or about a spina bifida. When the skin is dissected off, the true sac of the tumor is met with. This is formed from the membranes of the cord matted together. No layers, however, can usually be made out, nor can the integuments be distinctly separated from the protruded membranes. In cases where the skin is quite normal, however, a layer of loose connective tissue often exists between the membranes and the most external coverings of the protrusion. Mr. Thomas Smith has recorded a remarkable case where the tumor contained two distinct sacs. The tumor, in this instance, was large and pendulous, and opened from the lower lumbar region. It was translucent, but presented no impulse on crying. The child was 14 months old, and, apart from the tumor, in perfect health. The mass was tapped, and 8 ounces of clear fluid drawn off. The patient died in ten days from spinal meningitis. At the autopsy, a second and smaller cyst was found at the upper part of the mass, that had not been punctured. Between the two cysts was a strong membrane, and in this position also ran the cauda equina. The bony opening was at the last lumbar vertebra. The larger or lower cyst communicated with the spinal canal and contained a few nerves. The smaller cyst led by a funnel-like process to the centre of the cauda equina and subarachnoid space.[1] Sir James Paget has also recorded a case of two sacs in a spina bifida, one inclosing the meninges and cord, and the other occupied by fibrous and fatty tissue.

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[1] Manual for the Practice of Surgery, 2d ed., vol. i. page 256.

[2] Traité de Path. Externe, tome iii. p. 709.

[3] Medical Gazette, 1838.

[4] Path. Soc. Trans., vol. ii. page 299. 1860.

[5] In a case recorded in the Boston Med. and Surg. Journ., July, 1862, page 456, the pedicle is said to have been "about a foot in length."

Contents of the Tumor.—The sac of a spina bifida contains more or less fluid, which is identical in composition with the cerebro-spinal fluid. There is no doubt, moreover, that this fluid and the fluid in the sac of the tumor are one. The fluid may be found either between the cord and its membranes (hydrorachis externa or hydro-meningocele), or may be found in the central canal of the cord (hydrorachis interna or hydro-myelocele). In the latter case, the cord is usually found spread out so as to form a thin covering over the wall of the sac, and its condition may be compared to that of the brain in severe hydrocephalus. Follin and Duplay believe that in at least three-fourths of all cases the fluid is formed within the centre of the cord. In all cases where the fluid has apparently accumulated in the central canal, an extensive spreading out of the substance of the cord is not necessary. In many instances the cavity of the sac has been found to communicate by a funnel-shaped opening with the central canal of the cord, while yet the thinning or expansion of the cord was very slight.[2] In all these cases the communication has been at the lower part of the medulla spinalis; and while it is probable that in these instances the fluid originally accumulated in the central canal, it is equally probable that the collection communicated at an early period with the subarachoid space. In some cases cerebro-spinal fluid may form the sole contents of the sac in spina bifida; but such cases are exceptional. As a rule, the spinal cord, or some part of it, and a certain number of the spinal nerves, are included in the protrusion. Follin and Duplay state that some nerve-tissue is found in the sac in five-sixths of all cases. Out of twenty cases of spina bifida, reported by Sir Prescott Hewett, in one instance only was the sac free from nerve-structures.[3] The relation of the cord or of the spinal nerves to the sac varies greatly. In some cases the cord may bend into the sac, and, having possibly contracted some adhesions there, may re-enter the spinal canal; or the cauda equina, with more or less of the lower end of the cord, may pass through the bony opening, and, entering the sac, become adherent to its inner wall. In such cases the termination of the medulla spinalis is often indicated by the point of its adhesion to the protruded sac; and this adhesion is, in some cases, marked by a depression on the outer surface of the cyst.

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[1] Trans. Path. Soc., vol. xxi. page 1. 1869.

[2] See drawing of a dissection in Bryant's Surgery, vol. i. p. 255.

[3] London Medical Gazette, vol. xxxiv. 1844.

Sometimes the cord-structure is found spread out as a thin coating of nerve-tissue over the inner surface of the cyst, a condition depending upon great accumulation of fluid in the central canal of the cord. In other instances the cord may be fairly sound, and the cauda equina may be spread out as a lining to the cyst wall; or the extremity of the cord may be, as it were, dissected up into bundles, and thus be made to represent an unduly large and coarse cauda equina. Sometimes only a few nerves are to be found in the sac, scattered about its posterior wall, or hanging loosely in the fluid with which it is filled. Speaking generally, the nerve-structures, when they occupy the sac, tend to observe, for the most part, the middle line and the posterior aspect of the tumor; and it may be said that the larger the opening in the bones, the more probable is it that a large amount of nerve-tissue will be found in the cyst, and *vice versa*. In spina bifida not only may the cord be defective, or its parts disturbed in the manner just indicated, but the great nerves concerned in the deformity may also show certain deficiencies. Thus, Dr. Fisher[1] found in two cases of spina bifida that he examined, a fusion of two or more of the sacral ganglia, and observed that the corresponding nerves passed through the spinal membranes in one bundle. South,[2] commenting upon this observation, says that he has himself verified it in a case which he examined after death following puncture. Some few, rare instances have been recorded where the sac contained, in addition to cerebro-spinal fluid and some cord or nerve-structures, a certain amount of fibrous and fatty tissue.[3]

SYMPTOMS AND DIAGNOSIS.—The tumor in spina bifida is congenital, is always in the middle line, and always closely and distinctly connected to the subjacent bone. In many cases the defect in the bone can be felt when the tumor is drawn away from its attachments. The tumor is round or oval, and usually of regular outline. It feels tense and elastic, and, as a rule, presents very distinct fluctuation. If the coverings of the cyst be thin, the mass may be as translucent as a hydrocele. The integument over the tumor may be normal, or may present any of the conditions that have already been described. The mass is generally constricted at its base, if not distinctly pedunculated. Careful attention must be paid to those symptoms that mark the connection of the cyst with the interior of the spinal canal. Chief among these symptoms are the following: The size and tenseness of the mass can be diminished by pressure. Such pressure will often cause evident pain or convulsions, or limited muscular spasms, and if continued may induce a state of coma in many instances. When hydrocephalus exists at the same time, pressure upon the tumor causes increased tension at the anterior fontanelle; and, in like manner, pressure at the anterior fontanelle produces some increase in the sac of the spina bifida. These mutual pressure-effects cannot be seen unless the head is hydrocephalic. If the pelvis be raised above the head, the tumor becomes softer, while its tension is increased during the act of crying. These evidences of a communication between the sac and the spinal canal are more marked in large tumors than in small, and in those without a pedicle than in those possessed of one. It will be obvious that the smaller the orifice between the sac and the canal, the less marked will be the evidences of the communication. The complication of hydrocephalus tends to render the symptoms of communication much more distinct.

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[1] London and Edinburgh Philosph. Mag., vol. x. p. 316. 1837.

[2] Chelius's System of Surgery, vol. ii. p. 466. 1847.

[3] Holmes's System of Surgery, 2d ed., vol v. p. 804.

Spina bifida is very commonly associated with some gross nerve disturbance, due to injury or defect in the cord or great nerves at the seat of the deformity. Thus talipes is very frequent, and especially talipes equino-varus. There may be a loss of power in the lower limbs that may present any grade from mere muscular weakness to absolute paraplegia. With this paraplegia there may be paralysis of the sphincters, although this latter symptom may exist independently of paraplegia. With the loss of movement in the lower limbs, more or less loss of sensation may be associated, and, as a rule, both movement and sensation are impaired together, the impairment of motion, however, being the more marked of the two. According to Follin and Duplay, there may be loss of sensation only in the lower limbs, but such a condition must be quite uncommon. In some equally rare instances the affected limbs are hyperæsthetic. Launay[1] has recorded a case where there was loss of both motion and sensation in the right lower limb, with loss of movement only in the left. Hydrocephalus is commonly associated with spina bifida, and in the course of any case convulsions are not infrequent. It is difficult to say positively, in all cases, whether the cord is or is not in the sac of the spina bifida. It may be safe to suspect its presence in the tumor, unless there are indications to the contrary. The larger the opening into the spinal canal, the more probably will the cord be found in the sac, whereas such a complication is but little to be suspected when the bony opening is small and the pedicle long and narrow. In those cases that are associated with hydrocephalus, the cord, or at least some part of it or of its main nerves, are very usually to be found in the cyst of the spina bifida. The existence of talipes, or of paralysis, the occurrence of convulsions, the readiness with which nerve symptoms are produced by pressure, are all in favor of cord tissue being associated with the protrusion.

Follin and Duplay have pointed out that when the termination of the cord is adherent to the posterior wall of the sac, the site of the adhesion is often indicated by a depression on the surface of the tumor in the middle line. In many cases also where the cord is adherent to the sac, its position is indicated by undue thickness of the cyst wall at one part, and possibly also by some loss of translucency. A vascular and reddened condition of the skin is said by some to indicate adhesion to the parts beneath.

It is probable that complete paraplegia will in all cases depend upon hydrorachis interna.

The *diagnosis* of spina bifida is rarely a matter of difficulty. The disease has been confused with certain tumors that have occupied the middle line, and have been congenital; but in such growths the laminæ and spinous processes of the vertebræ have been felt intact beneath the tumor, and it has been possible to demonstrate the absence of any adhesion between the tumor and the bone. In such cases, moreover, there has been an absence of those symptoms that indicate a communication between the tumor and the spinal canal. Sometimes the sac of a spina bifida becomes cut off from all communication with the vertebral canal, and then the diagnosis between such a cyst and a congenital cystic growth in the middle line is practically impossible. Not only is the diagnosis often impossible in such cases, but it is also quite unimportant, inasmuch as the treatment in the two affections is identical. The points of difference between spina bifida and certain congenital growths in the regions common to spina bifida, will be dealt with hereafter.

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[1] Bull. de la Soc. Anat., 1859, page 342.

PROGRESS AND PROGNOSIS.—The common tendency of spina bifida is towards rupture of the sac. The tumor usually increases steadily, and in time reaches such dimensions that the skin or coverings of the protrusion give way. The contained cerebro-spinal fluid is then discharged, and death very commonly follows from convulsions, or less frequently from inflammation of the spinal membranes. The rate at which the tumor increases varies greatly, and can hardly be definitely laid down. In several instances the sac has ruptured *in utero*, and the infant has either been born dead, or has survived its birth but a few hours or days. Often the tumor has given way during birth, and its contents have been discharged with a more or less rapidly fatal result. Sometimes the rupture is represented by but a small hole in the skin; this heals and the sac refills. In such a case, a second rupture of the sac may end in death, or the opening caused by the rupture may remain patent and a fistula be established that is, however, soon attended by a fatal termination. In certain instances the contained fluid may escape through the greatly thinned skin without any opening being apparent. In the minority of all cases spontaneous cure takes place. Such a cure is most likely to occur in cases where the tumor is small, possessed of a small and narrow pedicle, and occupied by no part of the cord, or of the great spinal nerves. In such a tumor the abnormal opening may gradually close, the fluid in the sac may be absorbed, and the mass may shrink and almost disappear; or this end may be brought about by some adhesive inflammation at the root of the tumor, whereby the obnoxious orifice is closed and a good result follows. Many cases are recorded where a complete cure has followed upon the spontaneous rupture of the sac, and Holmes cites a case where a like fortunate result followed upon the suppuration and bursting of the cyst in a child aged six months.[1]

The tumor may increase in size for years, and then suddenly cease to grow, and begin to exibit a retrograde movement that in time will end in a cure of the deformity.[2]

In the Transactions of the Pathological Society[3] is an account of a case where a spina bifida, the size of the patient's head at birth, was rapidly undergoing spontaneous cure at the age of twelve months. Patients with spina bifida have reached the ages of 28, 37, 43, and 50 years.[4]

TREATMENT.—The treatment of spina bifida may be classed as *palliative* and *curative*.

Palliative treatment consists simply in protecting the part from friction or injurious pressure, and in retaining in as healthy a condition as possible the coverings of the protruded mass. These ends can be best effected by enveloping the mass in a pad of cotton-wool smeared with vaseline, and secured to the part by means of a circular bandage so applied as to exercise some pressure upon the tumor. By these simple means the growth of the tumor has been arrested or greatly modified, the amount of inflammation in the skin has been lessened, and any progressive thinning of the cyst-wall has been considerably retarded. I believe that this very rudimentary plan of treatment is better than that of keeping the part constantly painted with collodion. The pressure exercised by the contracting collodion is slight and superficial, the application itself often increases rather than diminishes the inflammation of the skin when it exists, and when that inflammation has proceeded to actual ulceration, I presume that the use of collodion would be very generally considered as inapplicable, even if possible.

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[1] Surgical Treatment of Children's Diseases, page 82.

[2] See a case in Med.-Chir. Trans., vol. xl. page 19, where the tumor continued to grow steadily for three years and then began to decrease.

[3] Vol. xvi. page 13.

[4] Case by Behrend, Journ. für Kinderkrankheiten, Bd. xxxi. S. 350.

Before any more active measures are proposed, it is well to consider the relations and surroundings of the tumor. The true spina bifida communicates with the cavity of the spinal membranes, and usually contains either the cord or some part of it, or a certain number of the lowest spinal nerves. Any operation, therefore, upon such a tumor must involve the spinal membranes, and probably the medulla spinalis itself, and it is unnecessary to point out that an operation with such incidents must be among the most serious that can be entertained in the practice of surgery.

In the face of these serious features in any operative proceedings for the relief of spina bifida, it has been pointed out that the cases most suitable for operation are those where the bony defect is trifling, the tumor well pedunculated, and the cord and its nerves free from any participation in the protrusion. This is obvious; but these very cases that are considered the best suited for operation, are the very cases that are the most prone to undergo spontaneous cure. I would venture to urge that the possibility of spontaneous cure in spina bifida has been a little too lightly estimated, and that, while perhaps harm may be done by temporizing with a case, that harm is not so very unevenly balanced by the mischief that has followed upon hasty, premature, and ill-conceived operations. There are not a few cases on record that, like the following example, would urge a greater tolerance of the possibility of spontaneous cure. A man, aged twenty, had a spina bifida that had of course existed from birth. It was of great size, but, apart from the inconvenience attending its large bulk, it gave him no trouble. For twenty years, then, it had caused no serious or even very troublesome symptoms. At the age of twenty, the tumor was tapped. With what result? Within six days of the second tapping the man was dead.[1]

Looking over the records of the treatment of this deformity, one is struck with the immense number of cases of spina bifida that have been subjected to operation within a few days—nay some even within a few hours—of the birth of the victim. In such cases, the possibility of spontaneous cure can hardly have been considered, and it remains with those who have undertaken such operations to show upon what grounds these apparently premature and hasty measures have been adopted. I would then urge a little patience as the first factor in the treatment of spina bifida. Let the first measures be palliative, and let operative measures be considered when some definite indications for further treatment arise. These indications may be afforded by the rapid growth of the tumor, by the probability of its speedy rupture, by the onset of convulsions or other nerve disturbance, or by the increase in a paralysis that has perhaps always existed to some extent.

The principal *curative* measures (so called) may be considered under the head of (1) Puncture, (2) Injection, (3) Ligature, and (4) Excision.

(1) *Puncture.*—There are many cases where the only symptom that requires to be immediately dealt with is the rapid increase in the size of the tumor, or in the degree of its tenseness. I think that such cases can—for a while at least—be very well treated by puncture. I might best illustrate the matter by reference to two cases at present under my care at the London Hospital. One patient is aged nine, and the other six months. Both tumors are in the lumbo-sacral region; they are both large, and have but thin coverings. In each case the skin is inflamed about the summit of the cyst, and has been many times ulcerated. There is reason to believe that the cord, or some part of it, has a share in the protrusion in each instance. For some weeks after

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[1] Trans. Path. Soc., vol. viii. page 10.

birth, the tumors were simply kept covered up with cotton-wool smeared with vaseline, and some slight pressure was maintained over the part by means of a bandage. The history and progress of the two cases are so similar that they may be treated as one. In time the tumor increased in size and in tenseness, the child became restless and convulsed, and the undue tension in the cyst appeared to be the cause of these fresh symptoms. The tumor was then tapped as far from the middle line as possible, with the finest trocar, and enough fluid (about 1½ drachms) let out to relieve the tension. The wool was then reapplied, and the pressure of the bandage again maintained. Immediate relief followed. In the child aged nine months I have thus punctured the cyst, I dare say, a dozen times, but the necessity for such punctures has become less and less frequent, and the operation has not been performed for the last three months. The tumor is now apparently stationary. The child is still—as it always has been—partially paralyzed in its lower limbs; but it has had no convulsions for months, and it is in fair health. As far as I can judge, there is in this case a large defect in the bone, and the cord is in the sac. But what operation can be done—as far as our present knowledge goes—to close this defect and restore the cord to its proper place?

To ligature or to excise the mass would probably be to ligature or excise the cord or some part of it, and I can hardly believe that iodine injection could loosen any adhesions that may exist between the cord and the sac, restore the cord to its proper canal, and close the defect in the bone. In the child aged six months, the tumor is increasing, but is kept within bounds by frequent tapping—sometimes once a week, or once a fortnight—and the child appears, apart from the tumor, to be well. I think, then, that in certain cases, the treatment by puncture and gentle pressure may be advised, not, perhaps, so much as a means of cure, but as a measure for prolonging life and rendering the existence of the patient less distressing than it might be. I can, however, well believe that it may in some cases lead to a cure, although a paraplegia or other gross nerve-lesion may persist. It would appear that the smallest possible puncture is the best, and that it should always be made, when available, through healthy skin. The less fluid drawn off at each operation the better. It is merely required to lessen the tension. The subsequent pressure should be slight and evenly applied. I believe that this treatment originated with Sir Astley Cooper. That surgeon at least reported two cases where he had adopted this measure and with very good success.[1] The practice of simple puncture, with evacuation of the entire amount of the contained fluid, is strongly to be condemned. It would appear to have led in most cases to severe and fatal convulsions, and in certain instances to almost sudden death. It must be remembered that puncture under any circumstances may be followed by inflammation of the sac.

(2) *Injection.*—This mode of treatment has so far been the most successful that has been made use of in this deformity. Many fluids have been used for injection, but the only one that has proved of any practical use is iodine. The tumors best suited for this method of treatment are those that present the condition most favorable for spontaneous cure, and it is in such cases that successful results have, for the most part, been obtained. When there is a free communication between the sac and the spinal canal, and when the cord or the large nerves enter into the protrusion, the success of the operation, and indeed its very advisability, are matters of considerable doubt. There are many who maintain that the treatment by injection is not justifiable when the hole leading from the sac to the cavity of the spinal membranes is

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[1] Med. Chir. Trans., vol. ii. page 324. Bryant, in his "Surgery," 2d ed., vol. i. page 257, gives an account and a drawing of a case cured by repeated puncture with a needle.

large and free, or when the contents of the cyst are other than simple fluid. If then only selected cases are considered suitable for this measure, its success must be estimated at a proper value. I am aware of no case of cure from iodine injection where it was distinctly proved that a free communication existed between the interior of the sac and the spinal canal, that could not be even temporarily cut off, and where at the same time the cyst contained the cord or some considerable portion of it. The methods of using this iodine treatment vary.

Brainard, of Chicago, adopted the following plan: Six ounces of the fluid in the cyst were drawn off, and half an ounce of an iodine solution was then injected. This, after a few seconds, was allowed to flow out, the sac was then washed out with water, and the operation was completed by the injection of two ounces of the original cerebro-spinal fluid that had been kept in the meanwhile at the temperature of the body. After the operation, pressure was applied. Brainard's solution consisted of iodine, 5 grs., potassium iodide, 15 grs., and water, one fluidounce.[1] Velpeau withdrew all the fluid in the cyst, and then injected a solution of tincture of iodine and water, after the manner adopted in the treatment of hydrocele. Morton's method appears to have the advantage over both these plans, and is probably the most successful method of using iodine that has been proposed. Morton uses a solution of ten grains of iodine and thirty grains of iodide of potassium in one ounce of glycerine. The operation is not advised until the child has passed over the "accidents of birth," unless a speedy bursting of the tumor is threatening. A little of the cerebro-spinal fluid is drawn off, and then from half a drachm to one drachm or more of the "iodo-glycerine solution" is injected. This is allowed to remain in the cyst. The puncture is then painted with collodion. The operation may need to be repeated several times at intervals of a week or ten days, or longer. Some little inflammation commonly follows each injection, but it usually remains limited.[2] If a good result follows, the mass shrinks, and soon ceases to give trouble. In a recent communication, Dr. Morton[3] states that, as far as he knows, 29 cases have now been treated by this method. Out of this number failure has occurred in six instances only, and from this Dr. Morton argues that the iodo-glycerine solution treatment has brought about a saving of life to the extent of 79.31 per cent. Before, however, this very pleasing conclusion is accepted, it would be desirable to have more full details as to the exact condition of the various cases operated upon, and especially as to the anatomical relations of the parts concerned in the tumor.

The failures from the injection treatment have depended upon inflammation involving the spinal membranes and cord, upon convulsions independent of such inflammation, or upon suppuration and premature bursting of the sac.

(3) *Ligature and* (4) *Excision.*—These operations can only be undertaken in those comparatively infrequent cases where the sac is quite free from either the cord or any of the spinal nerves. The smaller the tumor, the smaller the bony hole, and the narrower the pedicle, the greater is the chance of success. The real danger is, that the inflammation incident upon healing and upon the closure of the aperture in the bony canal, may extend inwards and extensively involve the spinal membranes. It would be of no avail to detail the many modes in which these operations have been carried out. The ligature has been applied gradually, and it has been applied suddenly. The mass has been allowed to fall off, and it has been taken off at once with the *écraseur*. Ex-

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[1] Am. Journ. Med. Sciences, vol. xlii. page 65. 1861.
[2] See Lancet, vol. ii. 1876, pages 776 and 881.
[3] Glasgow Medical Journal, 1881, page 401.

cision has been preceded by ligature; excision has been performed with or without the preliminary use of a clamp. It has been executed in a great variety of ways: by excising the whole, or by excising a part; by invaginating the collapsed membranes, or by cutting them off close to the bone. It has been followed by the use of the cautery, and by the application of divers kinds of suture. It has, indeed, been practised with all the ingenuity that is a feature in the history of so many surgical procedures.

The *modus operandi* is of little moment. If the sac contain cord-elements, the result will prove fatal; if not, success may possibly follow. The operations are, as far as surgical science at present goes, restricted to cases that present in a marked degree the elements necessary for spontaneous cure, and to cases where that cure has so far advanced that the opening in the bones has become closed, and the tumor gives trouble only by its bulk. If the ligature be used, a superficial cut should be made in the skin at the base of the mass, and a silk ligature should then be applied and drawn sufficiently tight to strangle the mass. In excising the cyst, it should be removed by an oval incision at its base, so planned that after removal the edges of the wound may come together in a clean, straight line. The operation should be done antiseptically, and firm pressure should be maintained until the wound has healed.

An account of the chief operations alluded to under this heading will be found in Mr. Holmes's monograph in his "System of Surgery," 2d ed., vol. v. p. 807.

False Spina Bifida.

This term has been applied to many different tumors that have, however, for their common characters a congenital origin and a communication with the spinal canal, but not with the spinal membranes. Some of these tumors are solid, some are multilocular cysts, and some are simple cysts. Both pathologically and clinically, they present striking points of difference, and as there appears to be no great advantage in classing these various growths under a common head, I would venture to question the value of this term in its present extended sense. The term false spina bifida should be applied to one tumor only, namely, to a spina bifida whose communication with the spinal membranes, and, perhaps, with the spinal canal itself, has been cut off. Such a tumor is the result of the process of natural cure in cleft spine, and of it many examples have been furnished. The false spina bifida will be found in some region common to this deformity—most probably in the lumbo-sacral region—will be of congenital origin, cystic in structure, and situated accurately in the middle line. It will present no evidence of communication with the spinal membranes; will be, in almost every instance, pedunculated; and will probably have been of some duration. There may possibly be a history to show that such a mass did at one time present all the features of a true spina bifida.

Lacking this fact in the history of the case, the *diagnosis* of false spina bifida is by no means easy. There are certain congenital tumors of a cystic character that may appear in the middle line in regions common to spina bifida, and that may furthermore have an intimate connection with the column. These tumors may closely resemble false spina bifida, but the resemblance will, in most instances, not be of long duration. The cystic tumor is usually multilocular; the false spina bifida a simple cyst. The cystic tumor is apt to grow rapidly, is usually not very distinctly pedunculated, often contains more solid masses in its interior, and is nearly always irregular and bossy in outline. The false spina bifida, on the other hand, tends to diminish rather than to increase in size; its pedunculation is nearly always very distinct; it contains no separate, solid masses, although it may present a uniform thickening of its sac; and lastly, its outline is nearly always quite smooth and regular.

The diagnosis, however, is of no great moment, as it would suggest no plan of treatment that, while applicable to a false spina bifida, would not be equally applicable to such a cystic tumor as would closely resemble the simple cyst.

Excision is probably the most suitable mode of *treating* these cases, and is the method that has been attended with the greatest success. Injection with iodine has been proposed, but would appear to have no great claim to attention, for the sac of the false spina bifida is often thick, and, even if the sac should become obliterated as a result of the injection, the cyst-wall would still remain with probably a considerable pedicle. If the case should prove to be a multilocular growth, the injection would then be obviously useless. On the whole, therefore, considering possible errors in diagnosis, a cautious excision of the mass is probably the most certain and the safest procedure.

Certain of the following tumors may be—and have been—mistaken for spina bifida.

Congenital Sacro-coccygeal Tumors.

The sacro-coccygeal region is peculiarly liable to be the seat of certain congenital tumors. Some of these grow from the sacrum alone, and others from both the sacrum and the coccyx, but the majority would appear to have their primary origin from the coccyx alone.

As to the reason why this region is so frequently the seat of congenital growth, nothing definite can be said. It is a problem that still requires to be worked out. It is remarkable that the congenital tumors about the sacrum and coccyx should be much more frequent in the female than in the male. Molk gives 58 cases in which the sex was noted, and of this number 44 were in females, and 14 in males.

These tumors are very varied in their external characters, and are, I think, best classed in the following manner: (1) Attached fœtuses, (2) Congenital tumors with fœtal remains, (3) Congenital cystic tumors of various kinds, (4) Congenital fatty, fibrous or fibro-cellular tumors, and (5) Caudal excrescences.

Attached Fœtus.[1]—The most common example of this condition is afforded by a third lower limb that is attached to the sacral region, and that hangs down between the normal legs of the patient. The condition has been known as "human tripodism." The superfluous limb consists usually of the two legs of another fœtus blended into one. The size and development of this additional member vary. It is usually dwarfed, and often contracted at the knee, and the foot, or feet, commonly much deformed. It may, however, appear well developed, and may even exceed the natural limbs in the degree of its development. In some instances, one of the natural lower extremities of the patient may be wasted and deformed, and in a condition but little better than that of the additional member. This abnormality is associated with certain alterations in the anatomy of the pelvis, and some variation is shown in the manner in which the additional limb is attached to the trunk. In certain less frequent instances, the attached fœtus has been represented by a confused, pendulous mass that exhibits the rudiments of several limbs.

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[1] Representations of the principal varieties of attached fœtus are given in Dr. W. Braune's Die Doppelbildungen und angeboren Geschwülste der Kreuzbeingegend. Leipzig, 1862.

Such an instance is represented by Braune in his well-known monograph (Plate 3, Figure 7). Usually the superfluous limb is obvious at birth, but it may be concealed for some time within a fibrous sac, and may thus resemble the cystic tumor with fœtal contents to be next dealt with. In two or three recorded instances of this condition, the child was born with a sacral tumor that continued for some time to increase, and then gave way, allowing a foot and leg to come out.

The *treatment* of these supernumerary limbs is by amputation. The chief difficulty in any such operation is the connection of the member to the pelvis. But in these cases a disarticulation is not necessary in all instances, nor is it of course desirable to in any way interfere with any pelvic abnormality. It is sufficient to remove the projecting part of the additional member, and this operation would appear from recorded cases to be both fairly simple and more than fairly successful.[1]

Congenital Tumors with Fœtal Remains.—These tumors present themselves under a great variety of aspects. Usually they appear as roundish or irregular tumors, pendulous from the sacro-coccygeal region, and covered with a thin and often purplish skin. Beneath the skin is a sac, lined with a smooth membrane, and within this sac is a certain amount of fluid, and fœtal remains of the most variable nature and aspect. These fœtal remains usually present themselves in the form of an irregular, solid mass, bony, pendulous, and imperfectly pedunculated. This mass is composed of fatty and fibrous tissue, and presents usually a number of multilocular cysts, variously disposed. Some part of the mass may present fingers or toes, or rudimentary limbs. In other cases the tumor may contain portions of bone, most usually portions of the vertebræ, or fragments of cartilage, with here and there some ill-formed and indefinitely arranged muscular tissue. In other instances the mass has presented a knuckle of gut, that has sometimes contained a material like meconium. Some few of these masses would appear to have been dermoid, and have contained hair, teeth, and fragments of bone.

These tumors may occupy the subcutaneous tissue, but usually they are more deeply seated, and they are, as a rule, closely adherent to the bone. They may communicate with the spinal canal, but such communication is quite rare. Sometimes they extend deeply into the pelvis, and a large congenital tumor may in addition be found in that region; their size varies greatly; they are apt to be pendulous, but are seldom well pedunculated. Stanley has reported a case where the tumor reached almost to the feet.[2] Braune has detailed the case of a girl, who presented a congenital mass of this nature that was pendulous and attached to the buttock by a stout pedicle. The tumor contained the rudiments of limbs. It increased in size, and at the age of 16 was 26 inches long, and weighed 20 lbs. It was then successfully amputated. These tumors usually grow after birth, and, as a rule, their growth is rapid. The skin covering the mass may give way, and the fœtal remains contained within may protrude. This may or may not be preceded by more or less inflammation or sloughing of the excrescence. In one or two instances these tumors have been associated with a spina bifida in the sacral region.

Sometimes the fœtal remains are not contained within a sac, but are freely exposed. Such a condition rather approaches that alluded to under the term "attached fœtus." Such tumors are very irregular in outline, and still more irregular in composition. They may present, in addition to much fatty and cystic tissue, the rudiments of limbs, portions of bone or cartilage, or representatives of the head and of the intestinal tract. A complex variety of such a tumor I have described in Vol. XXXIII. of the Pathological Society's Transactions.

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[1] For an account of the cases operated upon, see Braune's work, and also an excellent article by Mr. Holmes, in his System of Surgery, 2d ed., vol. v. page 801.

[2] Med.-Chir. Trans., vol. xxiv. page 235.

Treatment.—These tumors have been subjected to many operations for the purpose of effecting their removal, but the most successful measure of this kind that has been proposed is excision. If the mass is considered suitable for removal, there is no better plan of accomplishing this than by the knife. The ligature is strongly to be condemned, and the galvanic cautery has no advantages over the knife, while it entails certain grave additional risks. These tumors are not extremely vascular, and such hemorrhage as has occurred during their removal appears to have always been readily checked. Excision of the mass is only to be advised in those cases where the tumor can be entirely removed without great difficulty, and without damage to neighboring important structures. These tumors are usually well defined at their origin, and show less inclination to invade the pelvis than do those which are treated of in the next section. They sometimes communicate with the spinal canal, and, unfortunately, the existence of that communication cannot always be foretold. In cases, therefore, where the mass is well limited as to its origin, where the pelvis is quite free, and where no communication with the spinal canal is expected, the tumor may be excised, provided that the general condition of the patient afford no counter-indications. Molk notes eight examples of removal of these masses, and of this number seven were successful. The statistics given by Holmes show a like good result. If the tumor be left, it will probably in time bring about a fatal result, the patient dying of marasmus, or of the effects of inflammation, suppuration, or sloughing of the mass. A great number of the subjects of these growths are born dead.

Congenital Cystic Tumors.—These constitute the greater number of the congenital tumors that are met with in this region. They present considerable differences, both in their external appearance and in their internal structure. Some few are single cysts, but the bulk are multilocular growths. The *single cysts* comprise spina bifida of the sacral region, and false spina bifida of the same locality.

It is well known that spina bifida in the sacral region alone is rare, and it has, I think, been tolerably well shown that coccygeal spina bifida does not, and cannot, exist. Into the features of spina bifida of the sacral region it is unnecessary to enter, after what has been already said. With regard to false spina bifida, it is probable that it constitutes the sole form of simple cyst in this region, or, perhaps, to be more precise, the sole form of deep-seated simple cyst. In a number of instances, these simple cysts in the sacro-coccygeal region have been shown to have been at one time directly connected with the spinal membranes, and the accounts given of other cases of simple cyst in this part do not appear to oppose the idea that they also are to be regarded as examples of false spina bifida.

The *multilocular cystic growths* form the most important series of tumors encountered in this region. They arise usually from the anterior surface of the sacrum or coccyx, and less frequently from the posterior surface of one or both of those bones. The size of the tumor varies greatly. It may be no larger than a walnut, or it may exceed the dimensions of the child's head. Some, indeed, have been enormous; and the bulk of these tumors tends to rapidly attain considerable dimensions. In outline they are roundish or oval, generally very irregular and bossy, and forming pendulous masses. There is usually a distinct pedicle in all those growths that have no extensive ramifications in the pelvis. The skin covering them is thin and transparent, and presents large and distinct superficial veins. The mass is usually of very unequal density, some parts being elastic or fluctuating, while others are firmer and more solid. The growth may communicate with the spinal canal, but such communication is quite exceptional.

When the mass grows from the front of the sacrum or coccyx, the latter bone is usually pushed backwards as the tumor develops, and may be so far turned back as to project beneath the skin. In other cases the coccyx is quite buried in the tumor, or it may be rudimentary, or even entirely absent. If the mass is of any great size, the anus and genitals are pushed forwards, and the rectum is sometimes found enveloped by the growth. The tumor may still further invade the pelvis, and its development within that cavity may be such that the pelvis may be filled, and the mass may then be found to occupy some part of the abdomen.

In structure, these tumors are, for the most part, composed of a number of cysts, varying in size from that of a pea to that of a horse-chestnut, and communicating more or less freely the one with the other. These cysts contain a fluid that resembles that of hydrocele, or they may be occupied by a gelatinous material very much like boiled sago-grains. These cysts are held together by a varying amount of firm, young, fibrous tissue. Some of the tumors may be composed solely of this cystic structure,[1] while others, and these are the majority, contain more or less solid tissue in addition.[2]

This solid tissue may be fatty or fibrous, or it may contain some particles of cartilage, or even of bone. Sometimes it preponderates in amount over the cysts, and the mass is rather a mass of fatty or fibrous tissue associated with some multilocular cysts than a tumor that can be fairly called cystic.

As to the real nature of these tumors, little that is definite can at present be said.

On microscopical examination, the cysts are found to be lined with cubical or columnar epithelium, and to be supported by a very cellular connective tissue.[3] This connective tissue, which would appear to be no other than embryonic connective tissue, has been considered by some to be sarcomatous in its nature, and upon these grounds a number of these tumors have been classed as sarcomata or cystic sarcomata.

Others, paying greater heed to the epithelial growth about the cyst-walls, have maintained that these tumors are to be regarded as cylindrical-celled epitheliomata, and are therefore to be classed with the cancers. I do not think, however, that either of these accounts of the nature of these growths has been by any means well established, and it still remains more than probable that these remarkable tumors must be regarded as the results of some abnormal and unknown phase in the tissue-formation of the fœtus. Some pathologists have endeavored to maintain that these growths are due to a degenerative process involving Luschka's gland. It is true that a vast number of these tumors take origin from the front of the sacrum and coccyx, and it is also true that no trace of Luschka's gland is to be found in these instances; but here the main facts end. It has never been distinctly proved that the tumor has actually had origin from this little body, a resemblance in structure between the two has never been fully established, and the loss of the gland by its becoming embedded in the growing tumor is not hard to understand. In spite, therefore, of the eminent names associated with this theory, it must still be regarded as not proven.[4]

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[1] See case by Mr. Shattock, Path. Soc. Trans., vol. xxxii. page 197. 1882.

[2] Hutchinson, Illustrations of Clinical Surgery, vol. ii. page 36. 1879.

[3] For some excellent drawings, see Path. Soc. Trans., vol. xxxii. page 197.

[4] See Mr. Hutchinson's work above referred to; also art. Sacro-coccygienne, by M. J. Chauvel, Dict. Encyclop. des Sc. Méd., 1878.

Such of these tumors as contain fœtal remains, serve to connect this series of tumors with those dealt with in the previous paragraph.

Progress, etc.—In many instances the children presenting these growths are born dead. A large number die within a day or so of birth. In those who survive, the tumor generally grows rapidly, and often very rapidly. The skin may give way in places, and the contents of the subjacent cysts be discharged. After such discharge the aperture may close, or further destructive changes may take place in the part. Bryant records a case where spontaneous cure followed upon the bursting of a cyst in this region.[1] As the growth advances, death may follow from marasmus, or from inflammation and sloughing of the mass, or from extension of the inflammatory process to the cord or pelvic viscera.

Treatment.—In the treatment of these tumors all partial measures are to be condemned. The practice of incising the mass is meaningless, useless, and pernicious. The tapping of a few of the cysts is equally futile. The excision of a part of the tumor only, leaves an inflamed and, perhaps, sloughing stump, from which fresh tumor-tissue will be produced should the child survive. In like manner, to ligature a portion only of the mass, is to do more harm than good, and the same criticism must apply to all attempts to destroy the tumor with caustics or the actual cautery. The mass should be removed entire, or left alone; and the most serious question involved in this matter of treatment is that concerned in the selection of proper cases for operation. The tumors best suited for operation are those in which a good pedicle exists, in which the base of the mass is comparatively narrow, and in which the tumor has neither extended into the pelvis nor is in communication with the spinal canal. Such cases are unfortunately quite the exception. Mr. Holmes has shown, however, that tumors of this nature can be removed even when they involve the pelvis, and extend into that cavity for no little distance.[2] The question therefore for the surgeon to decide is whether he can remove the entire mass without inflicting such an injury upon the pelvic structures and viscera as no operation would justify. It is impossible to give definite data for the decision of this question. Each case must be judged upon its own merits. It is very often difficult to make out the limits of the entire pelvic growth, although much may be learnt by a rectal examination. Apart from this matter of the pelvis, the possibility of the mass communicating with the spinal canal must be considered, although the evidence that will point to such communication is usually of the scantiest.

Of the various methods available for the removal of these tumors, that of excision is undoubtedly the best, and is the operation that has given the most favorable results.[3]

Congenital Fatty, Fibrous, and Fibrocellular Tumors.—These growths are not common in this situation, although several examples of each kind have been recorded. They resemble in character the congenital tumors met with elsewhere, that are composed of fatty, fibrous, or fibrocellular tissue, and present the same features with regard to diagnosis, prognosis, and treatment. They may be tolerably superficial, but as a rule have a deep origin. Molk cites five cases of lipomata arising from the front or tip of the coccyx. Sometimes these congenital fatty tumors may be very large, and one case is recorded where such a tumor formed a pendulous mass that reached the calves. In another instance the fatty growth involved the pelvis, and reached such dimensions as to almost fill that cavity.

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[1] Manual for the Practice of Surgery, 2d ed., vol. i. page 259.

[2] British Med. Journ., March 23, 1867.

[3] See Holmes's System of Surgery, vol. v. p. 802.

The most interesting examples, however, of lipomata in this region are afforded by those that have communicated with the spinal canal, a complication of great rarity. Mr. Athol Johnson has reported the case of a child aged 10 months, from whose sacral region he excised a fatty tumor that was increasing, and becoming ulcerated on its surface. The mass was found to extend into the spinal canal through a hole in the sacrum large enough to admit a forefinger. Within the canal the mass was found adherent to the membranes, from which it had, indeed, to be dissected off. The child recovered from the operation. The only evidence of cord complication previous to the operation was an occasional convulsive movement in the right leg.[1]

Mr. Thomas Smith has recorded a case of congenital lipoma growing from the coccyx, that is said to have closely resembled a spina bifida. The mass was at birth the size of a small egg, but in four months it had reached the size of a fœtal head. It was successfully excised by Mr. Smith.[2]

These tumors, except in those rare instances where they encroach considerably upon the pelvic cavity, should be removed at as early a period as convenient, and no better means is afforded for such removal than by excision.

CAUDAL EXCRESCENCES.—These are of two kinds: (1) bony appendages composed of supplementary coccygeal vertebræ; and (2) certain fibrocellular tumors that assume the form of a tail. Of the former kind Molk gives two examples. Of the latter several instances have been furnished. The tumor in these cases grows from the coccygeal region, and is composed usually of fibrocellular tissue. It contains no bone, and springs from the subcutaneous connective tissue. Being long, narrow, and perhaps pointed, it resembles the tail of some animals. Gosselin[3] quotes a case where the appendage was five centimetres (two inches) in length, and was curled forwards along the perineum. Chauvel[4] also gives a case where the excrescence was of the same length, and of the thickness of a little finger. These tumors are all readily removed with the knife.

In addition to the works of Braune, Holmes, Hutchinson, and others already alluded to, reference may be made to the following monographs dealing with the subject of congenital sacro-coccygeal tumors: Molk, Des tumeurs congénitales de l'extrémité inférieure du tronc, Strasburg, 1868, Thèse, 3e série, No. 106. Duplay, Des tumeurs congénitales de la région sacro-coccygienne, Arch. Gén. de Méd., 1868, tome xii. Wagstaffe, St. Thomas's Hospital Reports, N. S. vol. iv. (1873), page 213.

ANTERO-POSTERIOR CURVATURES OF THE SPINE.

Under this term are included two precisely opposite conditions, viz., *cyphosis*, or a curving of the spine backwards, and *lordosis*, or a curving of the column forwards.

CYPHOSIS.—In this condition there is abnormal curvature of the column, or of some part of it, directly backwards; and as the term "curving backwards of the spine" is open to some varied interpretation, it is necessary to add that, in all cases, the abnormal curve has its convexity directed posteriorly. Cyphosis may involve the whole of the column, although, as a rule, but a portion of it is implicated. In the majority of instances, indeed, it consists merely in an exaggeration of the posterior curve that normally exists in the dorsal region. Cyphosis may be temporary or permanent.

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[1] Path. Soc. Trans., vol. viii. page 16.

[2] Ibid., vol. xxi. page 334.

[3] Clinique Chirurgicale, tome ii. p. 665.

[4] Art. in Dict. Encyclop. des Sci. Médicales.

Etiology.—In dealing with the etiology of cyphosis, it will be most convenient to classify the causes of the affection according to the period of life at which it has commenced.

The cyphosis of *infants* and of quite young children depends for the most part upon rickets, and consists of a very general and equable curving backwards of the whole column. This rachitic curvature will be treated of hereafter. Quite independent of rickets, however, cyphosis may be developed at this period of life, and under such circumstances will depend upon a normal muscular weakness, if such a term can be allowed. It is well known that the spine at birth is straight, and that the curves that normally mark the adult spine are the result of a subsequent development, and are dependent upon the establishing of a proper equilibrium in the erect posture. For a considerable time after birth the erect position is not required. The normal posture of an infant, indeed, is the posture of lying flat upon its back. Thus it happens that the spinal muscles long remain but imperfectly developed, and it will be seen that the spinal column in infancy may readily be induced to assume almost any species of curvature. In cases of general muscular debility, some cyphosis naturally develops when the erect posture is attempted, and that cyphosis is, indeed, but the outward sign of an inability on the part of the muscles to properly support the spinal column.

A cyphosis from a like cause, will commonly develop in the backs of infants who are continually being nursed in the sitting posture. Such a position is unnatural, and the spinal muscles are usually unable to retain the column erect; the child's spine yields to the pressure of the superincumbent weight, and a more or less extensive posterior curvature is the result. Besides the pernicious habit of nursing infants in the sitting posture, some mothers take particular pleasure in making their children sit upright at as early a period as possible. They appear to consider that an ability to assume this position is an evidence of precocity and rapid development, and is an accomplishment to be fostered as tending to strengthen the back. The result, however, is often a very definite cyphosis, that may become more or less permanent. It must be allowed, however, that the posterior curvature that may develop in the spines of infants and young children shows some tendency to more or less correct itself when the child begins to walk, and begins in consequence to develop those curvatures that are normal to the adult spine.

A cyphosis may develop about *puberty*—especially in weakly girls—either, it would appear, from debility of the spinal muscles in common with the other muscles of the body, or from an undue or disproportionate use of those structures. The causes of cyphosis at this period are, probably, very nearly identical with those that tend to produce a lateral curvature of the spine. The child, perhaps, is engaged for a long time in a sitting posture without proper support to the back. In learning the pianoforte, or in the ordinary routine of school life, this position is often assumed for hours at a time. The muscles, either from inherent weakness or from undue use, become wearied, the back aches, and the child throws the burden of supporting the column upon the ligaments that are not susceptible to a sense of weariness. To effect this the back is arched backwards, and a temporary cyphosis produced; but in time the over-stretched ligaments yield, the elements of the column undergo slight structural changes, and the curve becomes permanent. Cyphosis is the position often assumed by the tired child who is compelled to still retain the upright posture, and it requires merely a frequent repetition of the malposition to render it definite and permanent. As active causes therefore in producing this form of cyphosis, one must recognize any debilitating influences, prolonged sitting or standing without support to the back, too early study, lack of proper muscular exercise, and, as some would urge, the early and continued use of rigid corsets, that, while mechanically supporting the spine, tend to discourage a proper development of the spinal muscles.

The cyphosis of *adults* may depend upon many causes. It may be induced by an employment that involves prolonged arching of the back, or prolonged stooping, or bending forwards of the head, or it may depend upon chronic rheumatic arthritis of the spine (spondylitis deformans). In most cases, however, the cyphosis of adults is secondary to some previous morbid condition, and is therefore "symptomatic," rather than "essential."

Thus, any disease involving frequent or prolonged dyspnœa may lead to some cyphosis as the result of an attempt to increase the chest capacity by an arching of the dorsal vertebræ. Asthma and emphysema are not infrequently associated with this form of curvature. Chronic painful affections of the abdomen may lead to cyphosis as to a means of relieving pain by avoiding pressure upon tender parts. Thus Follin and Duplay[1] enumerate metritis and chronic peritonitis among the causes of cyphosis.

Muscular rheumatism, either by directly causing contraction of the flexors of the spine, or by rendering the extensors painful and thereby to some extent useless, may lead to this posterior curvature of the column. Jacques Delpech[2] records the case of a man, aged 25, whose back became so arched and rigid from rheumatism that he could not support himself without crutches. Gymnastic exercise was advised, and in time a complete cure followed.

Cyphosis is very common in the *aged*, and especially among the laboring classes. It depends in many instances upon a general enfeebling of the muscular system, with probably some loss of elasticity in the elastic tissues. Not infrequently it is the result of chronic rheumatic arthritis, and the case figured by Dr. Agnew,[3] of an old woman with general cyphosis so severe that when in the sitting posture her chin touched the knees, was probably of this nature. In other instances the arching of the back has been determined by the patient's employment, or by some of the causes just detailed.

Lastly, it must be remembered that cyphosis may be hereditary, and this remark especially applies to a limited cyphosis of the upper dorsal region.

Pathological Anatomy.—Cyphosis may be general or partial. If general, the whole of the spinal column is involved, including even the lumbar region, but this form of the disease is quite rare. The great majority of the cases of cyphosis are of limited extent, and are restricted to the dorsal region. Such instances of limited cyphosis consist indeed merely of an increase in the natural curve of the dorsal spine. The curvature is most usually about the centre of the dorsal region, the summit of the curve being represented by one vertebra among the 5th, 6th, 7th, or 8th; and of these it would appear that the 6th dorsal vertebra is the one that most commonly marks the greatest point in the curvature.[4] The curve, however, may involve the upper dorsal region alone, or the dorso-lumbar region alone, or all the vertebræ from the cervical to the lumbar may be implicated in the deformity. It is also to be remarked that cyphosis may coexist with lateral curvature of the spine or scoliosis. In the slighter forms of the disease, there is merely some relaxation of the vertebral ligaments, with a separation of the laminæ and spinous processes, but without any gross alteration in the bones themselves. In marked and confirmed examples of this deformity, the anterior common ligament is found to be contracted, while the posterior ligaments of the column are relaxed. The individual bones have become altered so that the bodies of

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[1] Traité élémentaire de Pathologie Externe, tome iii. p. 726. Paris, 1868.

[2] De l'Orthomorphie, ou Recherches sur les difformités et sur l'art orthopédique. Atlas. Paris, 1828.

[3] Principles and Practice of Surgery, vol. ii. page 867. Philadelphia, 1881.

[4] Bouvier et Bouland, Dict. Encyclop. des Sci. Méd., art. Rachis. (Déviations.) Paris, 1874.

the vertebræ are somewhat wedge-shaped, being thin in front and thick behind. This latter change is due not to hypertrophy of the posterior segments of the bodies, but to absorption of their anterior parts, and involves a diminution in the proper height of the column. In cases of limited cyphosis, those vertebræ alone are altered in shape that form the summit of the curve, but in the more extensive examples of the deformity a number of the vertebral segments may be involved.

It is commonly asserted that, in extensive and long-standing forms of the disease, the spine may become fixed in its false position by anchylosis.

I believe that all such cases of cyphosis, attended with bony outgrowths and anchylosis, are dependent upon chronic rheumatic arthritis, and are more properly to be considered under the head of spondylitis deformans.

In confirmed and well-marked cyphosis, from whatever cause, there is usually some corresponding deformity in the thorax. The ribs, while somewhat separated behind, tend to come more and more in contact in front, and the whole thorax tends to increase in its antero-posterior diameter at the expense of its transverse dimensions. If the curve be in the dorsal or dorsolumbar region, the thorax may incline towards the pelvis, and the ribs become more vertical in direction. The sternum, being compressed in its vertical axis, becomes bent, and usually this bend is of such a nature as to present a concavity forwards. The pelvis may follow the spine, and become so vertical as to almost efface the sacro-vertebral angle, but more commonly it tends to assume rather the horizontal direction for compensatory purposes, and thus to increase rather than diminish the angle at its junction with the spine.

Diagnosis.—The recognition of this deformity is attended with no difficulty. In the common, dorsal cyphosis the back is arched, the head poked forwards, and the chin turned towards the sternum. The shoulders are commonly raised and unduly prominent, a prominence that depends mainly upon the removal from the chest wall of the inferior angles and posterior borders of the scapulæ. In severer cases, the entire back may be arched, and progression and even standing may be impossible without some kind of artificial support. In any case, backache is frequently complained of, and the constant false position may lead to or at least augment certain visceral troubles.

Mr. Adams[1] remarks that, in many instances, he has observed the cyphosis of young children to end in vertebral caries with angular projection of the spine. The diagnosis of this deformity from that due to Pott's disease is, as a rule, a matter of simplicity. In cyphosis the curve is truly a curve, and not an angular prominence of one part of the spine. The curvature, moreover, is extensive and uniform. There is no muscular rigidity of the spine, but rather all the vertebral muscles are flabby, wasted, and relaxed. There is no tenderness about the part, no sign of abscess, no evidence of cord implication. Cyphosis, moreover, is most common among the aged, at a period of life when Pott's disease is comparatively unknown.[2]

Treatment.—Cyphosis in the young is, for the most part, readily cured, but in the old it depends, in nearly every instance, upon causes that are scarcely to be influenced by any treatment. In dealing with the spontaneous cyphosis of the young, it is necessary to remove, in the first place, the cause of the malady. Prolonged sitting or standing, or prolonged poring over books or work, must be forbidden. The general health should be, if possible, improved, and especial attention paid to the development of the muscular system. Outdoor exercise should be enforced under certain restrictions, and gymnastic movements, calculated to call into moderate and varied use the vertebral muscles, are to be strongly advised. The great point, indeed, to be aimed at, is the more efficient development of the muscles that should support the spinal column erect. It may be of some use to stimulate these muscles by baths, friction, or electricity, although properly directed exercise is, without doubt, the more important feature in treatment. The patient should sleep upon a flat, horse-hair mattress, and during the day should assume for a certain time the dorsal decubitus. The practice of lying for an hour or so daily prone upon the face will also be of service. Instruments and supports of all kinds should be avoided as calculated to do harm by inducing still less activity of the spinal muscles. In very severe cases, however, where the deformity is considerable, the use of instruments may be sometimes advised as a preliminary measure, and the circumstances requiring their use are identical with those that point to instrumental treatment in cases of lateral curvature, which is considered in another article. Upon the treatment of nonessential or symptomatic cyphosis, it is unnecessary to comment.

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[1] Lectures on Curvature of the Spine. London, 1865, page 83.

[2] See under Pott's disease, *infra.*

Lordosis.—This term is applied to a curving of the spinal column anteriorly, of such a nature that the convexity of the curve projects forwards.

With the exception of certain cases of congenital deformity, lordosis involves only a portion of the spine, and is therefore always "partial."

It is usually met with in the lumbar region, and in that position consists merely in an increase of the natural vertebral curve.

Etiology.—Lordosis may depend upon many causes. A certain amount of lumbar lordosis may be hereditary. "Congenital lordosis" is a condition met with in certain monsters, and is accompanied by deformities that are usually incompatible with any but the briefest existence. It may be met with in any part of the spine. If in the cervical region, it usually depends upon some cranial deformity; if in the dorsal or lumbar regions, upon some thoracic or abdominal defect. The curve in these cases is usually abrupt and extreme, and in some instances the lordosis may so involve the entire spine that the head rests upon the sacrum. Some lumbar lordosis, more or less of a temporary character, may depend upon position, in cases where undue weight is thrown in advance of the line of gravity of the body. Thus it may be seen in cases of peddlers and others who continually carry trays in front of them, and in ascites, in pregnancy, in ovarian disease, and, as a somewhat more permanent condition, in great obesity.[1] The great majority of the cases of lordosis are compensatory to some other deformity elsewhere that deflects the line of gravity of the body. Thus arises a lumbar lordosis to compensate a forced flexion of the thigh, in instances of hip-disease. For like reasons is lordosis met with in congenital or unreduced dislocation of the head of the femur, in rickety deformities of the pelvis, and in rickety curvatures of the lower limbs. A lordosis may occur at almost any part of the spine to compensate an angular projection of the column developed at some other part. Cervical lordosis may depend upon the contraction of the scar after burns about the posterior part of the neck.

Mr. William Adams figures a case of lordosis associated with a lateral curvature of the column, and like cases are referred to by others.[2] Then again this deformity may depend upon paralysis. The paralysis that leads to lordosis may involve either the flexors of the spine (the abdominal muscles), or the extensors of the spine. In the former instance, the column is drawn backwards by the unresisted sacro-vertebral muscles, and in the latter instance the body is thrown back to enable the patient to walk while the abdominal muscles prevent the backward movement from being extreme. There is a form of lordosis that depends upon rickets, and that constitutes a chief feature of the rachitic spine. It will be alluded to in a subsequent paragraph.

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[1] Maisonabe (Journ. des difformités, No. 2, 1825) gives two cases where the lordosis of pregnancy persisted after confinement.

[2] Op. cit., page 74, fig. 10.

Cases of lordosis are sometimes met with that are open to considerable conjecture as to their nature. A case of this kind was lately under the care of my colleague, Dr. Warner, at the London Hospital. The patient was a little girl, aged nine, with a considerable amount of lumbar lordosis. She was a deaf-mute, but was otherwise in all respects well developed. There was no evidence of rickets nor of syphilis. She walked with a curious and unsteady gait, like a doddering old man, placing the sole at each step flat upon the ground at once. There was no definite paralysis of any muscles, and the child would run and play about all day without becoming unduly tired. She was very intelligent. The hip-joints, and all the muscles of the lower limbs and back, appeared normal. It was asserted that the lordosis had been noticed since the child had learned to walk. The greater part of the spinal deformity disappeared on suspension, or when the child was placed in the recumbent posture. The condition remained unaltered during the year or so that the child was under observation. In this case, the defect would appear to have been in the motor nerve system, and whatever the defect might be, it was probably congenital, or developed soon after birth.

Pathological Anatomy.—In marked cases of long duration, the posterior spinal ligaments are found contracted, and the anterior common ligament stretched. The spines and transverse processes of the affected part may touch, or be crowded together. The intervertebral disks may be increased in thickness in front, but it does not appear that any absorption of the posterior segments of the bodies is usual, or even common. The sacro-vertebral mass of muscles is often found contracted and rigid; and the psoas muscle, on the other hand, in a state of fatty degeneration from disuse. In lordosis of the lower portions of the spine, the pelvis tends to become more vertical, and the sacro-lumbar angle more prominent. If the dorsal region be much involved, the thorax may become deformed by a diminution in its antero-posterior diameter. In some cases the spinal column may be rigidly fixed in the abnormal position by a bony anchylosis of its parts, although such a circumstance is of much less frequency in lordosis than it is in the opposite deformity before treated of.

This anchylosis may take the form of stalactitic outgrowths from the transverse processes and spines, of such a character as to bind adjacent vertebræ together. In other cases the articular processes may be anchylosed, and in another set of instances bony outgrowths from the margins of the bodies themselves may serve to immobilize the affected portion of the spine. Du Verney[1] records a case of extensive lordosis of the dorsal and lumbar regions of the spinal column, where the intervertebral disks were ossified, and the whole spine thereby rendered rigid. The account given of this case, however, is very meagre. It is probable that in some of the instances of lordosis, characterized by the outgrowth of stalactitic processes, a chronic rheumatic arthritis of the part is the cause of the condition.

The *diagnosis* of this curvature is extremely simple. It is impossible to be mistaken, if in any degree well developed. The in-curved back, the erect carriage, the prominent belly, are all very familiar as usual concomitants of lordosis in its most common position—the lumbar spine. A more difficult matter is to determine the cause of the deformity; but as this subject would involve a discussion of the symptoms of many very difficult diseases, it can hardly be dealt with in this place.

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[1] Traité des Maladies des Os, tome ii. p. 117. Paris, 1751.

The *treatment*, in perhaps the majority of instances, is simply negative. In many cases the lordosis is compensatory to some permanent and incurable deformity, and is an advantage rather than a detriment to the patient. In few cases, indeed, is it of itself a cause of any great trouble to the individual who presents it. It would be obviously absurd to attempt to treat the lordosis depending upon abdominal tumor or pregnancy, although the curvature sometimes due to obesity may perhaps be lessened by supporting the pendulous abdomen with a proper belt. Cases due to prolonged false position of the spine in connection with some special employment, may obviously be relieved by discontinuing that employment. Lordosis depending upon muscular weakness may be treated on the general plan advised in speaking of cyphosis. In no cases—except, perhaps, in those of confirmed paralytic lordosis—are instruments of any kind desirable, and even in these cases they can do little more than help to retain the spinal column erect.

THE RACHITIC SPINE.—Before leaving the subject of antero-posterior curvatures, some slight notice may be taken of the common changes in the spinal column in rickets.

For a full account of the pathology of this disease, and of the various deformities which it causes, the reader is referred to the article on Rachitis,[1] and to that on Orthopædic Surgery. The spine in rickets may become the seat of certain curvatures that are nearly always in the antero-posterior direction. The nature of the curve is, to a great extent, influenced by the age of the patient at the time of its commencement. It must be remembered that at birth the vertebral column is without curve. The natural curve, such as it is, of infancy, is a general curving of the back, a slight cyphosis. This curve is seen when the infant is placed in the sitting position, and is the natural effect upon the column of the superincumbent weight. The earliest deformity of the spine in rickets, the deformity that appears at a time before the child begins to walk, is simply an exaggeration of the natural infantile curve. When the rickety child assumes the sitting posture, the whole back becomes curved from the neck to the loins. This curve is by no means permanent, and, indeed, at once disappears if the patient be suspended by the arms. It is due simply to a disproportion between the weight the column has to support, and the means it possesses to effect that support. The essential and primary defects in the column itself depend upon certain changes in the bodies of the vertebræ, upon certain defects in their growth and method of development, in the yieldings of enfeebled ligaments, in the failure of still more enfeebled muscles, and, as some would add,[2] in an abnormal softness of the intervertebral disks. The cyphosis of rickets is most marked in the lower dorsal region, is seldom severe, and is not very apt to become permanent and irremediable. Indeed, as the child begins to walk, fresh mechanical influences are brought to bear upon the column, and the abnormal curvature may be replaced by the normal curves of the developed spine, or by an exaggeration of those curves. If the child has commenced to walk at the time that the rickety change involves the spine, then the deformity produced will, as first hinted, consist in an exaggeration of the normal curvature that should develop when the child is first able to support the body in the erect position. Thus a lordosis in the lower segments of the spine

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[1] See Vol. I. page 251.

[2] Senator, Art. Rickets, Ziemssen's Cyclopædia of Medicine, vol. xvi. page 194.

will appear in the place of a cyphosis in the middle segment. Thus, as Mr. Haward expresses it, cyphosis is the curvature of a rachitic infant, lordosis the curvature of the older child.[1] It must also be borne in mind that spinal curvatures may develop in rickets as the consequence of a deformed thorax, a deformed pelvis, or deformed extremities.

In the matter of *treatment*, it is only necessary to observe that the *general* measures recommended in the article on Rachitis must be carried out. With regard to any *local* treatment, the recumbent position should be advised, to be maintained every day for a period that must vary according to the age of the patient, the degree of the curvature, and the general circumstances of the case. As the child's general health improves, the vertebral muscles must be encouraged in their development by moderate and careful exercise; and this end may possibly be aided by friction of the parts, by baths, and, in some cases, possibly by galvanism. In no instance should any apparatus be applied. If the curve be rapidly on the increase, that tendency must be met by insisting on the patient maintaining as far as possible the recumbent posture. To encase the spine in any rigid apparatus would but foster still further inactivity in the muscles, and favor a still further degree of feebleness in their action. If the disease have ceased all active progress, and the curvature alone remain, a return to the normal condition of the spine can be more readily and more surely brought about by improving the muscular condition of the back than by applying an apparatus. The apparatus, while it might remove the *appearance* of the curvature, would still tend to perpetuate its potential existence, and possibly leave the column as deformed at the conclusion of the treatment as it was at the commencement.

The subject of *scoliosis*, or *lateral curvature of the spine*, is treated of in the article on Orthopædic Surgery.

SPONDYLITIS DEFORMANS.

The term "spondylitis," from the Greek σπόνδυλος, means simply inflammation of a vertebra, and is therefore equivalent to the term "vertebral osteitis."

In this sense the word was first used, and it is still so employed by many, although the term has been by no means generally accepted in English surgical literature. The inflammatory process, when it involves the bones of the spinal column, is apt to assume many aspects and to lead to several very distinct clinical conditions. Although it might be well, from a pathological point of view, to consider all inflammatory changes of the vertebral bones under one common heading, such a course would be extremely inconvenient when the clinical aspects of the disease came to be considered. It might be, perhaps, more scientific to consider such conditions as Pott's disease, osteo-arthritis of the occipito-atloid joint, or necrosis of the odontoid process, under the general heading, "spondylitis," but upon clinical and descriptive grounds the arrangement would not be advisable. The use of the term therefore—in at least its proper sense—would appear to present few and doubtful advantages.

With regard to the term "spondylitis deformans," it would be assumed, from what has just been said, that it referred to an inflammation of the vertebral bones leading to deformity. It would be a synonym therefore for such an affection as Pott's disease. But by the aid of that mysterious power that appears to influence the selection of scientific terms, the title spondylitis deformans has been applied to one definite disease, viz., chronic rheumatic arthritis of the vertebral articulations. There are not many who would allow this disease to be ranked with simple inflammations; and even if it were an inflammatory change, it could hardly be said to be essentially a change involving the bones. Still the term has been accepted, and very generally accepted, and, as has occurred before, scientific accuracy must give way to custom.

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[1] Treatise on Orthopædic Surgery, page 100. London, 1881.

Spondylitis deformans, then, is the term used to denote chronic rheumatic arthritis of the vertebral column. An account of the general pathology and symptoms of this disease will be found in the article on Diseases of the Joints.[1]

Etiology.—This disease is met with usually in later middle and advanced life, and slight grades of the disease are of much more common occurrence than is generally supposed. In the subjects, for example, brought to the dissecting-room of the London Hospital Medical College, I have met with many examples of this vertebral affection, and believe that a slight degree of the disease is one of the commonest causes of the cyphosis of old age. Spondylitis deformans is sometimes met with at an earlier period of life. Dr. Allen Sturge[2] records a severe case in a man aged 26, and states that Eulenberg has met with a typical instance of the disease in a patient aged 12 years. Dr. Todd also mentions the case of a young girl who had chronic rheumatism of all her joints, and anchylosis of the spine. Many instances have been recorded in patients about thirty.

With regard to sex, the affection is much more commonly met with among males than among females. Occupation would appear to have some influence in the etiology of the disease, spondylitis deformans being more common in those whose employment involves frequent stooping or arching of the back.

As may be supposed, it is of more common occurrence among the poor than among the well-to-do, and its appearance may in some cases be very possibly influenced by exposure to cold and damp. In at least the severe cases of spondylitis, there is a history of rheumatic tendencies in the patient's family.

Pathological Anatomy.—In this disease the spine becomes curved and rigidly fixed in the abnormal position. Any part of the column may be involved, and in not a few instances the entire spine has shown evidence of the disease. The lower dorsal and lumbar regions are, however, the portions most commonly affected, and next in frequency comes the upper cervical region.

The pathological changes are identical with those that indicate chronic rheumatoid arthritis in other parts, and are marked in the main by absorption of the articular cartilages, by the outgrowth of nodular masses of dense bone, and by the occurrence of a certain amount of true or false bony anchylosis.

Among the earliest changes in spondylitis, is some absorption of the intervertebral disks, and the development of osteophytes from the bodies of the vertebræ. These osteophytes are most common at the sides of the bodies, between the edge of the anterior common ligament and the transverse process. They grow as rounded masses from the contiguous margins of adjacent vertebræ, and, meeting opposite the middle of the intervertebral disk, become locked together, and in time may fuse in firm, bony anchylosis. In the mean while the disk between the vertebræ becomes shrunken, friable, and of a duskier color. In some cases it may entirely disappear, and the vertebræ it once served to separate may then become firmly anchylosed together.[3] In this way portions of the column may become converted into a solid, bony mass. The lateral osteophytes just alluded to may attain considerable size, and are often singularly symmetrical on the two sides. In addition to these outgrowths, or independent of them, irregular, bony masses may form in front of the vertebræ, apparently in the substance of the anterior common ligament, and may also serve to bind contiguous bones together. Such a bond is more often effected by the locking of the osteophytic processes than by their actual fusion, although the latter condition is to be met with.

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[1] See Arthritis Deformans, page 369.

[2] Clinical Society's Trans., vol. xii. page 204. London, 1879.

[3] Bouvier et Bouland, Dict. Encyclop. des Sc. Méd., art. Rachis (déviations), Cyphosis.

With regard to the articular processes, they become denuded of cartilage; the bone, thereby exposed, becomes more or less eburnated; osseous masses form about the rim of the bone; and the process may end in true bony anchylosis, or in a firm locking of the joint by the development of the osteophytic masses. Dr. Hilton Fagge[1] records a case of rigid cyphosis in a man aged 34, where there was complete bony anchylosis of the articular processes in the dorsal region, together with firm union of the corresponding laminæ and spines by means of coarse, new bone. The bodies in this case were free from any osteophytic growth, but were so rarefied and wasted that the spine was fractured after death by the simple act of placing the body in the coffin. Bouvier and Bouland, speaking of anchylosed cyphosis, allude to the occurrence of this fusion of the laminæ and spinous processes, but insist, at the same time, upon its extreme rarity.[2] In some instances the costo-vertebral joints are affected, and the ribs become firmly anchylosed to the spine. As a result of the above-mentioned changes, the column becomes arched posteriorly, and a more or less extensive cyphosis is developed. This curve is generally quite regular, and its extent will, of course, depend upon the extent of the disease.

I have met with two or three instances, in specimens obtained from the dissecting-room, where the cyphosis was associated with a certain amount of lateral deviation, the lateral curve being, like that in the antero-posterior direction, quite rigid. The fixity of the column in its false position is a very marked feature of the disease. The changes observed in the bones themselves are all usually most marked about the summit or greatest concavity of the curve.

As a result of the curvature, of the bone changes, of the absorption of the intervertebral disks, etc., the entire column becomes diminished in height; and, as a result of its rigid condition, the muscles about the back atrophy, and often become very shrunken. The bony masses that are developed about the affected district may press upon the nerves, as they issue from the intervertebral foramina, and lead to a limited paralysis; and, according to Senator,[3] the spinal deformity may be of such a character as to cause compression or irritation of the cord with its attendant consequences.

Spondylitis deformans in the upper cervical region is attended with like changes in the atlo-occipital and atlo-axoid joints. The articular cartilages and the intervertebral disks may become absorbed, osteophytic deposits form about the rim of the affected joint-cavities, and a rigid anchylosis, that may depend upon fusion of the bones involved, is the common and the final result. In some cases, where the axis is conspicuously affected, the odontoid process may be found irregular in outline and greatly enlarged. No curve is formed when the disease attacks this region, but the joints become fixed, and the movements of the head being thus more or less restricted, a constrained position is assumed. Lastly, at least one case has been put on record of degeneration of the cord following disease in this portion of the spine.[4]

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[1] Trans. Path. Society, vol. xxviii. p. 201. London, 1877.

[2] Loc. cit.

[3] Ziemssen's Cyclopædia of Medicine, vol. xvi. 1877.

[4] E. Rotter. Deutsches Archiv f. klin. Med., Bd. xiii. S. 403. 1874.

Symptoms.—The disease usually commences with pain in the back. This pain may be severe and radiating, and of the character of rheumatic pains. In Dr. Sturge's case the onset of the pain was so sudden and severe as "to take away the patient's breath." It will soon be noticed that the back is becoming stiff, and that the patient has some little difficulty in stooping, or in moving the head. There is no tenderness of the parts, nor is there of necessity any actual pain when movements of the spine are attempted; but the stiffness is very conspicuous and irksome, and some "rheumatic pains" about the back may be more or less constant. After a prolonged rest the column will usually appear unduly stiff; and on the other hand, after extensive movements, the back may, in the earlier stages of the disease, appear more lissome, and be moved with less discomfort. As time goes on, the patient begins to lose his upright carriage; he appears diminished in height, acquires a constant stoop, and develops an antero-posterior curvature of the spine, with the convexity backwards. The cyphosis that results from this disease is generally well marked, of regular outline, and often of considerable extent. Its conspicuousness, moreover, is accentuated by that wasting of the sacro-vertebral muscles that in time ensues. The curve may be of such a character that the patient prefers to support himself with a stick when walking; the abdomen projects, and the shoulders appear often unduly prominent, owing to the scapulæ being more or less separated from the chest-wall in consequence of alterations in the thorax. If the upper cervical vertebræ are involved, the movements of the head become limited to a variable extent, the chin is poked forwards, and that constrained position is assumed which is familiar in cases of disease about the summit of the column. The rigidity of the spine, when the malady is well developed, is usually very marked, and may be absolute.

The thorax becomes more or less rigid, and may assume the deformity detailed in the paragraphs on "cyphosis." The fixity of the ribs may depend not only upon the alteration in the dorsal spine, or the formation of osteophytes about the costo-vertebral joints, but upon actual anchylosis of those joints. In the latter instance the breathing is entirely abdominal, as it was in the case recorded by Dr. Hilton Fagge, and alluded to above.

In spondylitis deformans there are usually evidences of chronic rheumatoid arthritis in some other part or parts of the body.

The duration of the disease varies. Its course is always chronic, and is to be estimated by years. The lighter grades of the disease have probably little effect in shortening the patient's life, and, as is well known, a good old age may be attained by those whose backs have been stiff and painful, and bent, for a good number of years. When the disease occurs in early or in middle life, the prognosis is by no means as favorable. Life may be considerably curtailed by the malady, and indeed, if it assume by any means a severe form, death usually results in a comparatively few years.

As regards *treatment*, it can only be asserted that the condition is incurable, and that neither local nor general measures are of any permanent or substantial value. Some relief may be given by the treatment, such as it is, that is usually advised in chronic rheumatic arthritis, and an account of which will be found elsewhere.[1]

Caries and Necrosis.

Caries and necrosis are both of common occurrence in the spinal column: but the former is, of the two, infinitely the more frequent. The large amount

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[1] See page 375.

of cancellous tissue that enters into the composition of the vertebræ, will explain the greater tendency of the column to caries, and for the same reason it follows that the bodies are the usual parts attacked by the malady. Necrosis, on the other hand, is chiefly met with in the posterior segments of the spine, and when occurring in the anterior portions of the column usually implicates such parts as contain much compact tissue, and therefore principally involves the first and second cervical vertebræ.

The matter of *caries* is fully discussed in the sections on Pott's disease and Disease of the Atlo-axoid region.

The principal and most frequent examples of *necrosis* of the spine are also detailed in those sections; and it only remains here to allude to such cases of necrosis of the column as cannot be well referred to either of these clinical divisions. These cases are but few in number, and are due probably in all instances to injury. Thus I have seen necrosis of several of the dorsal spines follow upon a severe laceration of the back, that had exposed and injured those processes.

A like necrosis has followed upon certain fractures and dislocations of the spine attended with crushing and comminution of the bones.

Mr. Bickersteth records a remarkable case of a man, aged twenty-two, who was shot in the neck. The lesion involved the fifth and sixth cervical vertebræ. After an interval of some months he became the subject of dysphagia and paralysis of both arms. The wound was open, and there was intense inflammation of the pharynx. He ultimately expectorated two small pieces of bone, and a dense mass of tissue that was discovered to be an intervertebral fibro-cartilage. A perfect recovery followed, although some stiffness of the neck persisted.[1]

INTERVERTEBRAL ARTHRITIS.

This term obviously implies inflammation of the joints between the vertebræ, and includes not only arthritis of the true joints between the articular processes, but also inflammatory affections of the intervertebral disks. The term is too general, and too wide in its application to be of use in any treatise that is founded upon a clinical rather than a pathological basis. It might be of great advantage in the light of pure pathology—to consider all forms of vertebral arthritis under one common heading—but such an arrangement would tend to confuse well-marked and familiar clinical outlines, and would be in direct opposition to commonly accepted notions of the varieties of vertebral disease.

The intervertebral joints that are the most commonly involved are those between the axis and between the latter bone and the occiput. These affections are fully discussed in the chapter on Diseases of the Alto-axoid Region. A special form of intervertebral arthritis is considered under the heading Spondylitis Deformans.

The principal and most common, inflammatory, or destructive processes in the intervertebral disks, are considered in the section on Pott's Disease, and it is necessary, therefore, in this place to do no more than call attention to some rare aspects of intervertebral arthritis that cannot be included under any of the above-mentioned headings. These examples of the disease are twofold: (1) Arthritis of the true joints of the spinal column following upon injury, and (2) certain peculiar cases of perforation of an intervertebral disk.

(1) The vertebral column is frequently the seat of concussions and sprains.

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[1] Medical Times and Gazette, vol. i. 1862, page 614.

These injuries must involve to some extent at least the joints that connect the various vertebræ together. If the more superficial joints of the body are exposed to sprain or contusion, they commonly enough become the seat of synovitis, and there is nothing in the structure of the joints between the articular processes of two vertebræ that exempts them from a like consequence. I believe, indeed, that simple synovitis of certain of the synovial joints of the spine, is common after sprains and contusions of the back, and that such a condition can probably explain the long-continued pain and stiffness that often persist after such injuries, and that are usually so very well localized. There is no reason to suppose that this synovitis is different from other forms of synovitis. It may be acute or chronic; and it may end in resolution or pass to suppuration. I am aware of no actual demonstration of simple synovitis of the vertebral joints; but many cases have been recorded of suppurative synovitis of these joints that has followed upon sprains and like lesions. The main symptoms are long-continued, local pain, and rigidity from the painfulness of movement and some amount of muscular contraction. I am well aware that these symptoms may occur in cases where the muscles only are lacerated or contused, and perhaps the ligamentous structures torn, but there is nothing to disprove the suggestion that in some instances these symptoms may be due to intervertebral synovitis. Shaw states that not only may this synovitis of the joints between the articular processes go on to suppuration, but the purulent collection thus formed may cause limited paralysis by pressure upon the nerves as they issue from their respective foramina. Moreover, the joint-abscess may burst into the spinal canal and lead to paraplegia and death.[1]

(2) Dr. John Ogle has placed on record two remarkable cases of peculiar perforation of an intervertebral fibro-cartilage that in each instance led to death from implication of the medulla spinalis.

The first case occurred in a man aged 50, who had presented no distinct evidence of spinal mischief until one day, while at his meals, a piece of a mutton bone became impacted in his gullet. This was easily disgorged, but the act was immediately followed by a paroxysm of coughing, during which much pus was brought up. He experienced also much pain in the neck. In process of time he became paralyzed—first in the upper and then in the lower extremities—and gradually sank, sensation having become impaired some few days before death. At the autopsy, a hole was found in the posterior wall of the gullet, that led directly to a perforation in the fibro-cartilage between the fourth and fifth cervical vertebræ. The perforation presented an ulcerated appearance, and had gone right through the disk, and so opened into the spinal canal. The cord and its meninges were inflamed.[2]

The second case was that of a woman, aged fifty-two, who suffered from post-pharyngeal inflammation connected with some slight erosion of the surface of the bodies of certain cervical vertebræ. She died from spinal arachnitis, and the post-mortem examination revealed a perforation in one of the cervical fibro-cartilages, that had extended back and opened into the spinal canal.[3]

POTT'S DISEASE OF THE SPINE.

NOMENCLATURE.—There is a well-known affection of the vertebral column that is most common in the young, and that is marked by certain very defi-

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[1] Holmes's System of Surgery, 2d ed., vol. ii. page 367.

[2] Path. Soc. Trans., vol. iv. 1853, page 27.

[3] Ibid., vol. xv. 1863, page 1.

nite, general features. The spine becomes rigid and tends to develop an angular deformity, an abscess with some peculiarities may form, paraplegia may ensue, and, after death, the anterior segments of the column will be found more or less extensively damaged by a destructive process. Various names have been given to this disease, and some explanation may be offered as to why the particular name that is adopted here has been selected. Among the terms applied to, or associated with, this malady, may be mentioned caries of the spine, vertebral tuberculosis (Nélaton), vertebral arthritis (Ripoll), osteitis of the spine, angular curvature of the spine, and Pott's disease.

The term "Caries of the spine" is very definite, but its very preciseness is an objection to its use in the present instance. The morbid process in this malady is indeed, in the vast majority of all cases, a caries of the bone, but at the same time cases are recorded where the bone has been exempt and the disease has been limited to the intervertebral fibro-cartilages. On the other hand, it can by no means be said that all cases of vertebral caries are associated with the general symptoms above mentioned, so that, if the clinical entity of the "Pott's disease" is to be maintained, the term now criticized is both too narrow and too wide. The terms "vertebral tuberculosis" and "vertebral arthritis" are to be discarded, inasmuch as they commit the user to certain very definite and limited views, in the one case as to the nature of the morbid process, and in the other as to its primary seat. The term "osteitis of the spine," on the other hand, is too indefinite to express the peculiar clinical attributes of the present affection. Inflammation is common enough in the bones of the column, but it is only in a comparatively small number of instances that that process leads to the definite disease known by many as Pott's disease. It would certainly be no gain to clinical surgery to forcibly associate this disease with such other forms of osteitis of the spine as necrosis of the spinous processes after injury, or inflammation of the odontoid body. The common and much used term "angular curvature" is open to the gravest objections. In the first place, the term is in itself ridiculous, involving, as it does, an obvious contradiction. An angular curve must, from a geometrical point of view, be classed with a square circle, or a round triangle. Then, again, the angular deformity is but one symptom of the disease, and that symptom, be it noted, not of necessity a constant one. Moreover, unwholesome ideas as to the treatment of the disease may be perpetuated by the prominence thus given to an important but isolated symptom. Finally, I would urge the use of the term "Pott's disease" upon these grounds. The meaning of the expression is well known, and its clinical associations are familiar. The term is extensively employed, not only in England and America, but especially on the Continent. In France, indeed, the title "mal de Pott" is the generally accepted name for this malady. Then, again, the term commits the user to no particular pathological opinion, and may be used by men holding the most opposed views in pathology, to express the same association of clinical features. Lastly, the term serves to perpetuate the name of a man who well deserves the honor, and who was the first to remove this disorder of the spine from the region of a confused ignorance, and from the especial province of the quacks.

ETIOLOGY.—*Age.*—Pott's disease may occur at almost any period of life. It has been met with in infants in arms, and in patients far advanced in years. Bryant,[1] indeed, details an instance where the disease attacked a fœtus in utero. The specimen is preserved in Guy's Hospital Museum, and shows "the bodies of three or four of the dorsal vertebræ . . . . clearly fused together from disease, giving rise to angular curvature." Cases, however, of Pott's disease at these extreme periods of life are exceedingly rare. The malady is usually met with between early childhood and adolescence, and in the great majority of all cases the disease commences between the ages of two and ten years. Instances are met with of the disease commencing in adults, but such instances are comparatively few, and the onset of Pott's disease in patients past middle life is very rare. This affection is indeed essentially a disease of childhood.

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[1] Manual for the Practice of Surgery, vol. i., 2d ed., p. 278.

Sex.—Sex appears to have little or no influence in the etiology of the disease. It has been asserted by many—and especially by those who urge a traumatic origin for Pott's disease—that it is more common in male than in female children. My own observation would lead me to believe that it is equally common in the two sexes, but Mr. Fisher's[1] statistics show a greater number of cases among females. These statistics are probably the most valuable that have been published. Of 500 cases of angular deformity treated at the National Orthopædic Hospital, 261 were in females and 239 in males. Allowing for the preponderance of females over males in the general population, these figures would make it appear that the disease is, perhaps, equally common in the two sexes, and would at least correct the assertion that the malady particularly affects boys.

Constitutional Condition.—Pott's disease is usually met with in unhealthy children, and especially in those who present that phase of ill health known as scrofula. It must be confessed that on this point there has been no small amount of dispute, and while some have urged that every case is directly due to scrofula, others have maintained that that diathesis has nothing to do with the production of the disease. Many of these discrepancies are to be explained by the various conceptions that are held as to the nature of struma. Those who expect every patient with Pott's disease to present a certain physiognomy, will certainly be disappointed, as will also those who may expect every such patient to present glandular disease, or to come of a decidedly "tubercular" stock, or to finally die of some tubercular malady. Scrofula, as I have tried to demonstrate in a recent work on the subject,[2] is rather a tendency to a peculiar form of chronic inflammation. Of the character of this inflammation I will speak subsequently. The diathesis is rather to be estimated by certain morbid tendencies in the tissues, than by any peculiarity of feature or descent. In support of the assertion that angular deformity is most usually met with in the strumous, I would draw attention to these facts. In a great number of instances, the patient's immediate relations are the subjects of acknowledged scrofulous disease. In many instances there is a history of phthisis or of tuberculosis in the family. The patient often exhibits some other evidence of a strumous habit. This may be seen by a tendency to chronic catarrhs, by the occurrence possibly of certain skin affections, or by a disposition, it may be, to certain glandular enlargements. In not a few instances I have notes of cases where the spinal disease was cotemporary with, or preceded or followed by, some such gross, strumous ailment as "white swellings" of a joint, or caries, or necrosis of some bone. Lastly, as I shall point out when dealing with the pathology of this disease, the morbid changes that take place in the vertebræ are very often identical with changes occurring in acknowledged scrofulous disorders. Some authors have objected to Pott's disease being classed among strumous affections, because many of those who suffer from the disease do not present at the same time great glandular swellings, or other strumous malady. A few do show these complications, while the majority do not; and the condition of these latter is, I think, to be explained by that antagonism that appears to, exist between the various strumous disorders, and that does not favor the appearance upon the same patient, and at the same time, of more than one gross manifestation of the disease. In the book just alluded to, I have endeavored to fully demonstrate this antagonism. While then, I would not for one moment insist that all the victims of Pott's disease are of necessity scrofulous, I would urge that the majority of such patients present reasonable evidences of this diathesis. I have, for example, met with several instances of this spine-affection in children who have appeared in perfect health as regards their general condition, and who have moreover presented no suspicion of struma in their families; but such instances are exceptional. Lastly, I believe it will be very generally allowed that Pott's disease is more common among the poor than among the rich, or well to do, and that it is most common in association with those general conditions which are the most favorable to the production of struma. Some few writers have maintained that angular deformity may be due to rheumatism or gout, but there would appear to be little or no foundation for this statement. On still scantier grounds has masturbation being assigned as a cause of this disease.[1]

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[1] Essays on the Treatment of Deformities of the Body, p. 11. London, 1879.

[2] Scrofula and its Gland Diseases. London, 1882. See also my article on "Scrofula," in Holmes's System of Surgery, 3d ed. London, 1882.

Injury.—There can be no doubt that injury bears an important part in the etiology of Pott's malady. In those cases in which the disease attacks children who are apparently in robust health, and who present no constitutional taint of any kind, I believe that an injury is to be assigned as the actual cause of the mischief in the spine. In those cases, moreover, in adults who appear to be in all other respects in perfect health, a history of injury, distinct and grave, is seldom, if ever, absent. The frequency with which the disease would appear to commence about the junction of a vertebra with its interarticular fibro-cartilage, supports the theory of an injury as an essential cause. For it is well known that the point of junction of a rigid with an elastic segment of a column is a point of weakness. Allowing, then, that an injury is, in certain cases, an essential cause of angular deformity, I doubt if the majority of surgeons would go further, and assert with Dr. Sayre that this disease "is almost always, if not always, produced through some injury to the bone or cartilage."[2] There must be very few children who reach the age of ten years without having met with some accident, trifling although it may be, in which the back has been, directly or indirectly, involved. Any inquirer who starts with a bias in favor of injury as an essential cause of Pott's disease, will not lack material to support his opinion. The only question is as to the value of that material. Of how many children at the age of ten, could it not be probably said that "so many months ago it fell and hurt its back," or "had a bad tumble," or "had something strike it in the back?" Those who maintain the importance of injury in this disease, must also accept the onus of explaining why Pott's disease is not more common than it is, and why a given injury will produce the malady in one child, while it has no permanent effect upon another. In scrofulous children, in children already predisposed by heredity or acquired defects to certain phases of chronic inflammation, it is easy to understand that a very slight lesion may excite a carious action in the vertebræ. Whether such a lesion is essential, or not, it is difficult to say, and still more difficult to prove. There is the further question as to whether this lesion must of necessity be "an injury" in the usual meaning of that word, or whether it may not be caused by undue use of the part, by dispro-

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[1] See, for example, South's edition of Chelius's Surgery, vol. i. page 280.

[2] Spinal Disease and Spinal Curvature, p. 2. London, 1877.

portion between the strength of the column and the weight it maintains, or by undue pressure exercised upon some especial part of the vertebral segments. Lastly, if traumatism were so essential a feature in Pott's disease, it would not be unreasonable to expect that some definite relation should exist, other things being equal, between the injury and the consequent disease. But no such relation exists. A severe, extensive, and acute form of spinal caries may occur with the absence of a history of any definite lesion, while, on the other hand, a severe injury to the back may be attended with no ill results other than those immediately connected with the accident.

Considered generally, the etiology of Pott's malady bears a very striking resemblance to the etiology of "white swelling," or strumous joint disease, and there is an almost complete identity between the various opinions that have been advanced as to the causes of the two complaints.

PATHOLOGICAL ANATOMY.—The morbid change that constitutes the essential feature of Pott's disease is, with some slight reservation, a caries or molecular disintegration of the vertebral bodies. This change may attack any part of the column, but is more commonly met with in the lower dorsal region than elsewhere. In some rare cases, two distant parts of the spine may be involved at the same time, or may be attacked independently at different periods. An example of this latter circumstance is recorded by Shaw.[1] Although the disease may be limited to a single vertebra, such an occurrence is rare, and in most instances many of these bones are involved, and often in very varying degrees. Bryant[2] reports a case where no less than twelve vertebræ were involved. The morbid process nearly always commences in the bone; it may, however, commence in an intervertebral fibro-cartilage, and there are some who assert that the earliest change may take place in the periosteum, or in the spinal ligaments. There does not appear to be any positive evidence to support the theory of the origin of this disease from the two last-named structures.

The whole pathological process in Pott's disease may be divided into two distinct periods or phases: first, the period of destruction or softening; and, secondly, the period of repair. The changes themselves can be best considered (1) as they affect the bone, and (2) as they affect the intervertebral cartilage.

I. PERIOD OF DESTRUCTION OR SOFTENING.[3]—(1) *Changes in the Bones.*—These changes consist in a caries that has some few peculiarities. The morbid action is singularly limited to the anterior segments or bodies of the vertebræ. The body may be extensively and even entirely destroyed, yet will the morbid action have little or no tendency to extend to the posterior segment of the bone, to the laminæ, the pedicles, and the various processes; seldom, indeed, does it extend as far posteriorly as the articular processes and intervertebral joints, although, as a somewhat rare occurrence, these parts of the bone may be involved. The disease may commence in any part of the body of the vertebra, or at several parts at one and the same time. Most usually the earliest changes would appear to be in the anterior part of the bone, not far from the anterior surface. Another common spot for the commencement of the disease is that part of the body of a vertebra nearest to the intervertebral disk. It must be remembered that this part of the centrum is an epiphysis, and the disease would appear in many cases to begin as an epiphysitis, as it is called. Certain it is, that for some time the mischief may remain limited to that portion of the bone which corresponds to the epiphysis. Follin and Duplay state that the earliest change in Pott's disease is often to be noticed about the posterior part of the body, near its junction with the pedicles; and other observers have cited the centre of the bone as a frequent spot for the commencement of the disease.

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[1] Holmes's System of Surgery, 2d ed., vol. iv. p. 112. London, 1870.

[2] Manual for the Practice of Surgery, vol. i. p. 277.

[3] After describing the process as it affects the bones and cartilages it will be well to include under this heading an account of the "deformity" and the "abscess."

The change itself would be described, in the language of the text-books, as an *osteitis interna*, or as a *caries fungosa*, and, very briefly, the following are the alterations that are to be noted in the part: A certain area in the cancellous substance of a vertebral body becomes congested, and all the spaces in the bone become engorged with blood. Into the immediate cause of this limited congestion we cannot now enter. This vascular disturbance is soon followed by grosser changes, which consist, in the main, of two distinct processes—a softening and breaking down of the bone structure, and a development of certain fungous granulations. To properly appreciate these changes, it is needful to recall to mind the fact that two elements enter into the formation of bone, viz., inorganic matter and an organic matrix. The relation which these two elements bear to one another may be compared to the relation that exists between the plaster and the laths in a lath-and-plaster wall. Just as the laths support or hold together the plaster, so does the organic matrix of bone serve to support the inorganic elements or lime-salts. Now, it is obvious that the morbid process in inflammation of bone must be limited to the organic matter of the affected tissue, and that the inorganic material can take none but a purely passive part in any pathological change. Inflammation, to speak roughly and generally, has a tendency, in the first place, to soften the tissue that it invades. When inflammation attacks bone—or, rather, when it attacks the organic matter of a bone—it softens that material, and one might almost say that it dissolves it. The result of such a change is, that the matrix is no longer able to support the inorganic elements, and the structure crumbles down, just as would a lath-and-plaster wall if it were possible by some process to dissolve out the laths without seriously disturbing the plaster. It is needless to say that this softening and disintegrating change is no mere chemical process, but is brought about by active changes in the part itself, and in the bloodvessels that are concerned in its nutrition.

Into the minute features of the process, it is unnecessary here to enter. Suffice it to say that the partition walls between neighboring cancellous spaces are broken down, and that one large and irregular space results from the fusion of several small ones. Thus, the bone becomes lighter and more spongy, more cancellous apparently in its structure, and more friable undoubtedly to the touch. These bony spaces are by no means empty, nor have they for contents but the *débris* that has resulted from neighboring disintegration. On the contrary, they are occupied by a "fungous" granulation-tissue that has been derived partly from the altered cell-elements of the bone, and partly from an exudation provided by the bloodvessels in the area of disease. The "fungous" character of these granulations can hardly be said to be apparent until there is such a loss of parts that they find themselves projecting from a free surface. These granulations are very intimately connected with the disintegration of the bone. Indeed, they appear to penetrate the parts and carry destruction in their wake. It is by them that the process spreads, and it is to them that the pathologist has turned for a clue to the nature of the entire process. When the disease reaches the periosteum, the granulations are described by Lannelongue as perforating that membrane, and as piercing it, as it were, often at many points. The periosteum, readily altered, would become a part of this granulation-material, and would in time be destroyed, as the bone had been destroyed. Thus would the bone be bared and an erosion in its substance be exposed, or a deeper cavity in its interior be made manifest. Such are the main features of this caries fungosa. The mischief most usually would appear to commence at some little distance below the surface of the bone, but in certain instances the layer of compact bone next to the periosteum has been credited with exhibiting the earliest evidences of disease. Possibly—as above remarked—the mischief may sometimes commence in the periosteum.

The gross and visible result of the carious change, however, is this: Irregular cavities are formed in the diseased vertebral bodies. There may be several cavities in the same centrum, or one only, and the situation of the loss of substance may vary considerably. If the cavity forms deep down in the bony substance, it may continue to increase until nearly all the cancellous portions of the body are destroyed, and nothing is left but the outer shell of compact bone. This probably soon gives way, and the cavity opens upon the surface. In other cases the destructive action may early make its way towards the surface of the bone, and lead to an excavation in the bone that, while comparatively small, is yet deep. It is remarkable that the carious process tends, with the very rarest possible exceptions, to progress towards the anterior surface of the bone, and not towards that surface that bounds the spinal canal.

It will be seen that these cavities and excavations will vary greatly in appearance. There may be a cavity deeply hidden in the bone. There may be a cavity near the surface, whose walls are formed partly by bone, partly by thickened periosteum and ligament. In other cases the anterior surface of the bone is laid bare, and thus are exposed erosions varying in extent and depth, or deeper and more cavernous losses of substance. As long as the destructive process is in any way active or progressive, so long will the walls of these cavities be lined by the granulation-tissue just alluded to. The contents of the cavities vary greatly according to the duration, and perhaps according also to the nature of the morbid process. In recent cases the contents may be laudable pus, or more usually curdy pus, made up of a thinnish opaque fluid, with flakes of a denser matter. Seldom, indeed, is the contained matter quite homogeneous. In less recent cases the contents may be thick or creamy, or still further inspissated so as to be caseous and firm. In any case there is usually mixed with the matter some bony *débris* that can be felt like grit when the contents of these cavities is passed between the finger and the thumb; and in certain instances this *débris* may appear as actual and visible sequestra.

Lastly, with regard to the extent of the disease in the vertebral column, regarded as a whole, the utmost diversity exists. As already remarked, only one body may be diseased, although, as a rule, many are attacked. The extent to which the individual centra are involved varies greatly. There may be merely a small cavity or excavation in each of the diseased vertebræ, or several of these bodies may be entirely destroyed, and no trace be left of them other than is provided by the undestroyed posterior segments. As a rule, the intervertebral cartilages are more or less extensively diseased, but cases are occasionally met with where extensive loss of several contiguous vertebral bodies is associated with little or no appreciable destruction of the intervening disks. In the place of deep excavations in certain of the bones, there may be found a superficial erosion involving the anterior and lateral surfaces of a number of the bodies, and it is remarkable that when such erosions exist they are seldom limited to a small portion of the column. Some further observations will be made upon this subject in dealing with the deformity that forms so important a feature in the disease.

Before leaving the matter of the osseous changes, it may be well to briefly discuss the *nature of the process* that leads to these changes. It is very generally allowed that the process is to be classed as a caries, but the great matter in dispute is, whether that caries is simple or tubercular. A vast amount has been written upon this subject, and a good deal of it to very little purpose. Many pathologists have insisted that there is a distinct tuberculosis of the spinal column, while they have at the same time allowed that in many instances the process is non-tubercular. Most elaborate distinctions have been pointed out as serving to distinguish the simple from the tubercular caries: but these distinctions, falling short (as they have until quite recent time) of microscopic demonstration, are for the most part useless and delusive. It has been urged that in the tubercular process the cavities formed are peculiar in their depth, in their walls, and in their contents. The presence of caseous collections has been considered absolute demonstration of tuberculosis, and little opaque specks have been pointed out in the inflamed bone as veritable tubercles. It is now known that tubercles in inflamed bone are bodies not to be criticized by the unaided eye, that the minute opaque specks are but altered inflammatory products, and that caseous matter by no means of necessity indicates a tubercular change. It is well known that tubercular action cannot be judged of merely by the destruction it effects, nor by the outline assumed by the excavations that it leaves. It is also well known that the simple factor of chronicity can so modify the inflammatory process as to lead to a great diversity of appearances.

The question then still remains, Is the pathological process in Pott's disease tubercular or not? If by "tubercle" be meant the "primitive or elementary tubercle" of Köster, the "tubercular follicle" of Charcot, or the "submiliary tubercle" of other authors, and if the presence of this body constitutes a tuberculosis, then is the caries in Pott's disease very often tubercular. In the fleshy granulations of the diseased bone, and in the altered soft parts that lie about it, genuine tubercles have been detected, and Lannelongue has quite recently demonstrated the manner in which the carious action spreads by the development of tubercular tissue.

It may, I think, be considered as distinctly proved that a local tuberculosis takes a part in at least some of the cases of Pott's disease, and, as far as I have been able to see, it probably takes a part in quite the majority of all cases. Unfortunately, a very grave and often most inappropriate clinical meaning has been attributed to local manifestations associated with tubercle. Any individual who presents tubercle in his body, is considered to be possessed with a very fatal ailment, and to be liable to death from the development of some more general and widespread form of tuberculosis. Into the nature of tubercle-producing processes I cannot now enter, but I have endeavored in the book already alluded to, to assign to them a somewhat more simple significance than they are usually credited with. As a matter of fact, the bulk of patients with Pott's disease, even if they do present tubercle in the spinal bones, do not die of general tuberculosis. Indeed, as far as my own experience goes, that form of death is tolerably unusual. Then again the fact must be recognized, that tubercle-producing processes may undergo spontaneous cure, and are, when quite local, susceptible to treatment. This has been fully demonstrated in the matter of scrofulous glands, which often present the most perfect forms of tubercle. I have endeavored elsewhere to show that tubercle is no neoplasm in any other sense than that it is an inflammatory neoplasm, and that it is the outcome of a peculiar and distinctive inflammatory process.

The main features of this inflammatory process are these: it is usually chronic, and is apt to be induced by very slight irritation, and to persist after the irritation that induced it has disappeared. The exudations in such a process are remarkable for their cellular character, and for the large size of some of their elements. Such exudations show also a remarkable tendency to resist absorption, and to linger in the tissues, the affected area becoming rapidly non-vascular. Among the common products of these inflammations are giant-cells, and, if a certain stage of the process be reached, tubercles. The tendency of the process is to degenerate, not to organize, and the degeneration usually takes the form of caseation. At the same time, these inflammations have a tendency to extend locally and to infect adjacent parts, and their products present certain peculiar properties when inoculated upon animals. Lastly, the great feature of the process is this: it tends to commence in and to most persistently involve lymphatic tissue, and so actively is the marrow or lymph tissue of bone involved in the condition now under notice, that this at first consists essentially in an inflammation of marrow. This account will, I think, very fairly represent the nature of the process in many cases of Pott's malady of the spine. It must, however, be confessed that this condition is not met with in all instances. It is not to be expected in the caries that may follow after injury in a robust person free from any disposition to tubercle-producing inflammations. Such caries will usually be more active in its progress, will show less disposition to indiscriminate spreading, will be surrounded by a barrier of healthier action, and will show a less degenerate condition of its products. On the whole, it will present a more favorable aspect of the disease, but, apart from such marked cases as these, it would be scarcely possible to diagnose the presence of tubercle with any certainty from naked eye appearances only.

(2) *The Changes in the Intervertebral Fibro-cartilages.*—In most cases of Pott's disease, the intervertebral disks share in the destructive change. These bodies become softened and friable, show more or less extensive and often irregular losses of substance, and may be so entirely destroyed as to leave no trace. In cases where many vertebræ are attacked by a superficial erosion, a like erosion is generally to be seen on the front or sides of the corresponding disks, or in the centre of the disk a large cavity filled with more or less fluid matter may be discovered, that may be fairly compared to the cavities formed in the bone. There is generally a disproportion between the amount of destruction in the bones and that in the intervening cartilages. As a rule, the destruction is most marked in the vertebral body, a condition to be explained possibly by the fact that the mischief usually commences in the bone and then spreads to the articular disk. In this way the bone may be found extensively destroyed, and the cartilage thereby laid bare, and marked by a certain amount of softening of its parts, and by some irregular losses of substance. If the bodies of two or three adjacent vertebræ are entirely destroyed, there will be probably no trace of the disks that once intervened between them, although, in some cases, fragments may still be detected among the *débris*, of such an outline as to faintly mark out the position of the lost centra. In exceptional cases the disease would appear to commence in the intervertebral fibro-cartilages, and those bodies may not only present the greater amount of destruction, but may exhibit the sole changes observed in the column. Broca[1] gives the case of a young man, whose spine, after death, showed superficial erosion of all the dorsal vertebræ, with destruction, however, of no less than nine of the intervertebral articulations. In the place of the fibro-cartilages was a whitish, pap-like matter, and some bony *débris*, derived probably from the rubbing together of the bared surfaces of bone. Chassaignac[2] reported a case, also in an adult, where there was no trace of any intervertebral disks between the second, third, and fourth lumbar vertebræ. The bones appeared sound,

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[1] Gaz. Hebdom., p. 298. 1864.

[2] Gaz. des Hôpitaux, p. 156. 1858.

and were anchylosed together. An abscess had formed, but it was in process of cure.

In an early volume of the Pathological Society's Transactions is an account of a case where the bodies of the six lower dorsal vertebræ were carious on the surface, but where little or no trace of the corresponding disks was to be found.[1] Mr. Adams gives the case of a man, aged 43, who died of lumbar abscess. There was no deformity of the spine. The only lesion found in the column was due to the entire disappearance of the disk between the fourth and fifth lumbar vertebræ. Between these bodies (which are described as a trifle "indurated") a gap existed that was exactly of the size and shape of the lost fibro-cartilage. The same observer records also a like case where the intervertebral cartilages between the tenth and eleventh dorsal and the third and fourth lumbar vertebræ had been entirely destroyed, without any corresponding loss of substance in the adjacent bones. In this instance there was a psoas abscess, but no deformity of the back. Mr. Adams believes that the disease may, from first to last, be limited to the cartilages between the vertebral bodies.[2]

Before dealing with the process of repair in Pott's disease, it will be necessary to give some account of two very conspicuous results of the process of destruction, viz., the deformity and the abscess.

The Deformity.—When the destructive process has attained a certain magnitude in the anterior segments of the vertebræ, a gap is produced that destroys the continuity of the column, as far, at least, as the part of it in front of the vertebral canal is concerned. It is obvious that the existence of such a gap would be incompatible with any great pressure upon the column, and, if the loss of substance were considerable, it would be scarcely compatible with the erect posture. What usually takes place in Pott's disease, therefore, is this: The column yields at the diseased point, it bends backward, the gap is eliminated by the approximation of the vertebra above the gap with the vertebra below, and in this way an angular projection of the posterior segments of the column is produced. It is needless to say that the development of this deformity is the most conspicuous feature in the disease.

While this falling together of the vertebræ about the seat of the disease is essential to maintain any degree of stability in the column, it at the same time serves probably to keep up and to aggravate the carious action. By this alteration in the configuration of the column, two diseased surfaces are brought in contact, and, more than that, are pressed together, and probably rubbed together. However injurious such approximation of parts may be, it is still very essential for the purpose of repair, and for the subsequent consolidation of the weakened spine. The projection—as above observed—is angular, and the apex of the angle usually corresponds to the posterior segment of that vertebra in whose body the destruction has been the most extensive. There is some relation between the extent of the deformity and the amount of disease, although that relation is by no means a constant one. If only one or two vertebral bodies are lost, but are entirely lost, a sharp angle is produced; but, on the other hand, if many bones are involved, and none of them to any great extent, a more rounded projection results, and a deformity more approaching a curve is produced. If the anterior segments of the column be examined at the seat of the deformity, very various conditions may be met with, depending upon the nature and extent of the destruction. Several vertebræ may be blended together in a confused mass, or two vertebræ, partly destroyed, may be found so pressed together as to have displaced backwards some fragment of a third and intermediate body more extensively destroyed than themselves. Or the vertebræ, in falling in together to close up the gap, may have included a sequestrum of varying dimensions that lies buried deeply in the angle of the deformity. Or, if the gap involve only the anterior half of the body of a vertebra, the posterior half may be found to have yielded to the superincumbent weight and to the inflammatory softening that invades it, and to have brought about the typical disfigurement by a bending or yielding of its parts.

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[1] Trans. Path. Soc., vol. iv. p. 7. London, 1853.

[2] Ibid., vol. v. p. 241. London, 1854.

Further details as to the deformity in this disease will be reserved until the symptoms of the malady come to be considered.

Abscess (*Psoas Abscess; Lumbar Abscess; Iliac Abscess, etc.*)—An abscess usually presents itself externally at some time in the course of Pott's disease of the spine. There are cases, however, where the malady runs its entire course and ends in anchylosis and cure, and yet no abscess makes its appearance. Such cases are not infrequent, but they cannot be regarded as any evidence of the existence of angular deformity without abscess. Probably in all these cases an abscess has existed at some stage of the disease. This abscess, as the cure has advanced, has itself undergone cure; its contents have become inspissated and caseous, or even calcareous; its walls have become shrunken and inert; and but meagre traces of a once large collection of matter have persisted. I am not aware of any specimen that can of itself offer an undoubted example of spinal caries without abscess, and although the matter may still be regarded as unproven, it is probable that in all instances some suppurative collection is formed. The importance of the abscess in Pott's malady cannot be exaggerated. It usually forms the most troublesome feature in the history of the case, and, more than that, it is directly or indirectly the most common cause of death in those who are afflicted with the disease. I propose to deal first with the mode of formation of the abscess, and secondly with the various forms of the abscess as determined by position, etc.

Formation of the Abscess.—Lannelongue[1] has described this process in considerable detail, and his account agrees in its general points with that most usually given by pathologists. He speaks of the granulations in the bone as penetrating the periosteum, and as spreading the disease in the parts outside that membrane. He speaks of the soft parts around as becoming inflamed and involved in the process, and as presenting granulation-tissue akin to that which has been developed in the bone. Indeed, he urges that the morbid process in the bone and in the soft parts outside it are identical, and are modified only by diversity of structure and opportunities for extension and development.

The *débris* and suppurative matters that result from the caries in the bone are first included, perhaps, within bony walls, and then within walls formed partly by the diseased bone and partly by the inflamed soft parts about it. Lastly, if the purulent collection acquires any magnitude, the wall that bounds it is derived practically from the soft parts alone, and the share taken by the bone in its limits becomes very insignificant. As the disease is in the anterior segments of the column, the abscess appears upon the front surface of the spine, not usually immediately in front—on account of the resistance offered by the anterior common ligament—but a little to one side of the body of the diseased vertebra. The collection will at first be small and sessile. As it increases, it tends to gravitate, and so move downwards on the spine. In this way it becomes pedunculated, and its fundus, or most dependent part, acquires dimensions quite out of proportion, often, to the size of its attachment. The abscess when in this condition has been aptly compared by Follin and Duplay to a leech, gorged with blood, hanging on to the column. The direction the purulent collection tends to take—viz., a direction downwards along the front of the column—is to be explained by gravity, by the less resistance offered in this position, and by the decided resistance offered to the progress of the abscess by the structures at the posterior part of the spine. The pathology of such an abscess is identical with the pathology of like abscesses elsewhere. It will be obvious that the abscess will at first occupy the hollow or angle produced by the deformity, and this circumstance will explain the fact that large collections of pus may form in front of the dorsal spine, in this disease, without any injurious pressure been exercised upon the lungs. The contents of the cyst vary. When small, the pus is usually curdy, and contains flaky matters with, possibly, some bony *débris*. When of large size, the matter may still present a curd-like appearance, although more usually it is tolerably thick and homogeneous.

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[1] Abcès froids et tuberculose osseuse. Paris, 1881.

Varieties of the Abscess.—There are cases where the abscess may remain closely adherent to the seat of disease at the spine, and after attaining a certain size may cease to grow. To such collections the name of *vertebral abscess* may be given. It is obvious that they could not be detected during life; that they would indicate but a comparatively slight or non-progressive form of the disease, and that they might afford examples of resolution or spontaneous cure. More usually, however, the abscess increases, and advancing towards the surface ultimately discharges itself from some part of the exterior of the body. Considerable variety is shown in the direction or route whereby these suppurative collections reach the surface, and this variety in routes has led to some variety in names. The situation of the bone-disease will obviously modify to some considerable extent the point at which the abscess will ultimately present itself.

If the disease be in the *cervical* spine, the abscess usually discharges itself at some point about the sides or back of the neck, although it may in rare cases present itself behind the pharynx (post-pharyngeal abscess), or open into the gullet or trachea, or pass down into the thorax, or wander to the anterior part of the neck. If the disease be in the *dorsal* region, the suppuration will usually follow the course of the psoas muscle, and thus reach the groin (psoas abscess). Or it may incline backwards and discharge itself in the loin (lumbar abscess); or it may extend no lower down than the iliac fossa (iliac abscess); or it may pass that district and reach the gluteal region, or the perineum (gluteal abscess, etc.). Even when all these routes are exhausted, the abscess may still present itself in other and more unusual situations. When the mischief is in the *lumbar* spine, the abscess most commonly points in the lumbar or iliac regions, or may follow the course of the psoas muscle, or present itself in one of the less usual situations to be hereafter described.

It will be most convenient to give a very brief description of each of these varieties of abscess depending upon Pott's disease.

Psoas Abscess.—This form of abscess is most usually met with in disease of the lower dorsal or upper lumbar region; but it may occur with spinal caries in any part of the dorso-lumbar portion of the column.

If the abscess commences in the dorsal region, the collection is placed behind the pleura, and gravitates along the front of the vertebræ until it reaches the diaphragm. It may pass through the diaphragm, either by creeping along by the side of the aorta, or by making for itself a passage through that partition by inflammatory absorption. Its subsequent course has been very ably described by Mr. Shaw.[1] "When the abscess," he writes, "has perforated the diaphragm and gained its abdominal side, it comes into relation with the heads of the psoas muscle. That muscle arises by one set of fibres from the sides of the bodies of the vertebræ, by another from the roots of the transverse processes; and stretched across both orifices in front are the ligamenta arcuata. As the abscess, therefore, travels downwards, it has to pass through a narrow strait; it is prevented from enlarging on the forepart by the resistance of the ligamenta arcuata, and at the back by that of the spine and lowest rib; hence, in order to proceed, it has to force its way in the line of the psoas muscle. That, however, can only be done by penetrating into its interior. It accomplishes this, in the first place, by inserting its most advanced part, like a wedge, between the two orifices; it then splits and distends the fibres, so as to form a cavity for the reception of the pus; the muscular fibres become incorporated with the walls of the abscess, and the psoas at length is converted, more or less thoroughly, into an abscess. But the muscle, charged with pus, does not expand equally in every direction. The fascia iliaca forms a kind of sheath for it; and this being particularly strong on the inner side, and united firmly to the brim of the true pelvis, prevents the growth of the abscess inwardly. On the outer side, however, the connections are loose; and there enlargement takes place freely. The abscess now chiefly occupies the hollow between the united fibres of the iliacus internus and psoas muscles on the inside, and the crest of the ilium on the outside. When the advanced part reaches the level of Poupart's ligament, a certain retardation occurs; and then a bulging will be observed along the line of the flexure of the groin. The abscess now perforates the abdominal walls. . . . . . . and the opening is invariably at one place, namely, behind Poupart's ligament, between the united tendons of the iliacus and psoas muscles and the anterior inferior spinous process of the ilium. The situation corresponds to the point of junction of the outer with the middle third of Poupart's ligament." The abscess then descends a certain way down the thigh, and opens usually about the insertion of the psoas.

By this process, the entire psoas muscle may be destroyed and converted into a mere bag of pus, but, no matter how complete the destruction, the branches of the lumbar plexus that traverse the muscle remain intact, and lie, dissected out, across the purulent cavity. This cavity is generally very irregular in its dimensions. Where it passes the diaphragm and the abdominal walls, it is usually narrowed into a small "neck," and there are many cases where the continuity between parts of the abscess-cavity has been destroyed by a temporary or permanent closure of the "neck" situate at the abdominal parietes.

The part of the abscess-cyst just above the perforation in the parietes is usually of considerable dimensions, and like dimensions may also be attained by the abscess in the thigh. On reaching the limb, the pus may leave the psoas, and extend indefinitely about the front of the thigh, forming a large collection of matter, or it may proceed down the limb and point at almost any part of the extremity. Erichsen, indeed, cites a case where an abscess, which took origin in disease of the dorsal vertebræ, opened by the side of the tendo Achillis.[2]

Sometimes the abscess cavity bifurcates high up, and the pus descends in both psoas muscles, forming a double psoas abscess; and the same condition may be met with where two abscesses form, one on either side, and descend independently towards the pelvis. Pus from disease of the lumbar vertebræ may enter the psoas muscle at any part of its length, and lead to the formation of a definite psoas abscess.

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[1] Holmes's System of Surgery, 2d ed., vol. iv. page 119.

[2] Science and Art of Surgery, 6th ed., vol. ii. 242.

Pus may leave the psoas muscle at almost any point, and lead to abscess in some other situation.

Lumbar Abscess.—This abscess usually has its origin from some disease of the lumbar spine. The pus, guided by the fasciæ of the part, passes along the posterior abdominal wall, in front of the quadratus lumborum muscle, and having reached the edge of that muscle, becomes superficial in the space bounded by the external oblique and latissimus dorsi muscles, the iliac crest, and the last rib; or the pus may pierce the quadratus, or proceed along its inner parts, and ultimately point behind, at the outer edge of the sacro-lumbalis muscle. A lumbar abscess may, however, be but an offshoot from a psoas abscess, or it may proceed from disease in the dorsal spine where the purulent collection has avoided the psoas entirely, and has proceeded direct to the lumbar region. Pus in this region also may avoid the fasciæ, and, escaping into the loose subperitoneal connective tissue, may set up a perinephritic or a pericæcal abscess.

The term *iliac abscess* is applied to a purulent collection in the iliac fossa, and such an abscess may be due to disease in either the lumbar or the dorsal spine. It may be merely an offshoot from a psoas abscess, or a psoas abscess may leave the muscle at the pelvic brim, and, entering the iliac fossa, continue to develop there. In other cases the pus may be directed to the iliac region by the aorta and common and external iliac arteries, or, in the case of lumbar disease, the matter may gravitate directly to this region.

Gluteal abscess is not common, and pus may reach this region in many ways. An iliac abscess may increase considerably, and in time mount up over the crest of the ilium, and so reach the gluteal region. Or pus may be conducted to the great sacro-sciatic notch by the common and internal iliac arteries, and may escape from that notch, either above or below the pyriformis muscle. In other cases, the matter may appear to simply gravitate to the floor of the pelvis and escape at any convenient spot. It may especially follow the great sciatic nerve, and, pursuing the course of that nerve, the abscess may reach as far even as the ham.[1] Lastly, the matter may pass towards the middle line, and may point in the perineum or ischio-rectal fossa.

Some idea of the relative frequency of these abscesses in spinal disease, may be gained from the following table by M. Michel:—[2]

He gives the following as the result of an examination of 48 cases of Pott's disease accompanied by abscess:—

In 39 of the cases the abscess was about the pelvis. In 6 it was in the neck, and in 3 it was found in the dorsal region.

Of the 39 abscesses about the pelvis—

- 13 were about the groin,
- 14 occupied the iliac fossæ and the upper and inner, or outer, part of the corresponding thigh,
- 1 appeared by the anterior superior spine of the ilium,
- 7 were in the lumbar region,
- 3 in the gluteal region, and
- 1 in the perineum.

Of the 6 about the neck—

- 1 was in the supra-clavicular fossa.
- 3 presented at the sides of the neck, and
- 2 were post-pharyngeal.

The 3 abscesses in the dorsal region appeared near the middle line, and by the sides of the diseased vertebræ.

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[1] Follin and Duplay, op. cit., tome iii. p. 666. 1868–9.

[2] Dict. Encyclop. des Sc. Méd., Art. Rachis. Paris, 1874.

Rare Forms of Spinal Abscess.—(1) In disease of the dorsal spine the pus may proceed more or less directly backwards, and present itself by the sides of the corresponding spinous processes. (2) In disease of the same region the matter may pass forwards beneath the pleura and along the intercostal spaces, and thus reach the anterior mediastinum. Here it may be discharged by the side of the sternum. If the collection occupy the precordial region it may receive pulsations from the heart. (3) Mr. W. Adams has recorded a case that I believe to be unique, where the pus pursued an upward direction. The case was that of a lad, aged 12, with disease of the last two dorsal and upper two lumbar vertebræ. There was angular deformity. The abscess took at once an upward course, and opened opposite the spine of the seventh cervical vertebra. (4) Mr. Shaw[1] has recorded a case where the abscess followed the course of the inguinal canal, and, presenting at the external ring, closely resembled a hernia. He cites, also, a like case recorded by Sir B. Brodie.[2] (5) Broca[3] has recorded a case where a psoas abscess opened into the hip-joint, having effected an entry through the anterior part of the capsule. (6) Leudet[4] notes an instance of the abscess opening into the spinal canal. (7) Several cases have been put on record where the abscess opened into the lung, and, in some of these instances, fragments of carious bone were expectorated.[5] In M. Michel's monograph, above alluded to, a case is quoted where the abscess opened both into the lungs and also into the œsophagus. (8) In many instances a collection of pus derived from some spinal mischief may open into the intestinal canal; and usually, if not always, into the colon. There may be an opening into the gut and one also through the skin, so that while pus passes from the rectum, some fecal matter may also escape through the cutaneous aperture. I have seen an example of this condition, and several cases have been recorded. Lallemand[6] has given the account of a man, aged 19, who developed an abscess in the ischio-rectal fossa. This ultimately became a fistula in ano. When subjected to operation, a number of pieces of necrosed bone were encountered. It was then discovered that the man had "a deformity" of the lumbar spine. It was supposed that in this case the abscess was spinal, and the pieces of bone derived from the vertebræ, but the evidence as to vertebral caries was very scanty, and the body was not examined after death. (9) A spinal abscess may discharge its contents by the urinary bladder; an account of a case presenting this complication is recorded by Shaw.[7]

The matter of implication of the *spinal cord* in Pott's disease will be considered with the "symptoms of the malady."

II. The Period of Repair.—While destructive changes are going on in the anterior segments of the column, a process of repair is to be observed about the posterior segments. An adhesive form of inflammation appears to be excited about these parts. The periosteum covering the spinous and other processes becomes inflamed, a like change takes place in the ligaments that pass between the various portions of the posterior vertebral segments, and in this change the adjacent connective tissue has also a share. In this way the laminæ, and the transverse and spinous processes that correspond to the diseased portion of the spine, become matted together by inflammatory material. As the change advances, the products of the inflammation organize, and the adhesion between the various parts concerned becomes much more intimate and

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[1] Loc. cit., p. 123.

[2] On Diseases of the Joints, p. 267.

[3] Bull. de la Soc. Anat., tome xxvi. p. 406.

[4] Ibid., tome xxviii. p. 253.

[5] See cases by Triquet (ibid., tome xxii. p. 450) and Deville (ibid., tome xxviii. p. 139); also case by Shaw (loc. cit., p. 125).

[6] Arch. Gén. de Méd., tome vii. p. 474. 1835.

[7] Loc. cit., p. 125.

strong. If at this stage the specimen be macerated, the bones in the posterior segment will be found to present here and there irregular bony outgrowths, the result of periostitis, but there will be no direct or indirect bony union between any two adjacent vertebræ. As the process of repair advances, ossification occurs in the fibrous material that has been formed, the periosteal new growths assume a greater magnitude, adjacent vertebræ become locked together by the contact of stalactitic processes, and in certain cases the posterior segments of several of the vertebræ about the seat of disease may be firmly blended by a true anchylosis.

This process of repair in the posterior segments of the column appears early in the course of the malady, and is seldom absent in any but the most severe cases. Evidences of it may be trifling, but they are usually to be noted.

The importance of this process cannot be exaggerated. By the time that the disease has so far advanced in the anterior part of the spine as to destroy, perhaps, several successive bodies, the process in the posterior segments will probably have brought about such consolidation of the column as to prevent that gross bending or breaking of the weakened spine that, without such consolidation, would be almost inevitable.

With regard to the reparative processes in the anterior portions of the column, it must be remembered that the parts lost in Pott's disease are never replaced, and that in no case—after either slight or severe destruction—can the spine ever quite return to its normal condition. If the gap formed by the loss of tissue be considerable, the vertebræ, in falling together to produce the deformity, lessen the dimensions of the cavity and help to expel its contents. Bony surfaces above and below the seat of disease are thus brought together. If the process of cure at once advances, the granulations that cover the exposed bone develop into fibrous tissue, and with this material the cavity in time becomes more or less entirely filled. In certain instances, some portion of the fibrous tissue may ossify, and a more or less complete union of true bone ensue. This true anchylosis, however, is of rare occurrence. If an abscess exists, its contents become more or less absorbed, what was once pus becomes putty-like or caseous matter, the cyst shrinks, its walls become greatly thickened and more fibrous, and by clinging close about the seat of the disease serve to bridge over any gap that may have formed, and to still further strengthen the weakened part. In some cases the absorption of the abscess-contents would appear to be very complete; and in other instances the purulent matter, after becoming caseous, may finally undergo a calcareous metamorphosis. The portion of the column that has experienced loss of substance is strengthened also by a thickening of the periosteum, and by a development of much fibrous tissue in such soft parts as are in the immediate vicinity. By the blending of these altered parts with the remnants of the abscess-wall, a very substantial support may be afforded.

In addition to these means of immobilizing the spine, the gap may be bridged over by stalactitic processes of bone formed by the vertebræ that immediately encroach upon the gap. Sometimes these bridges of bone may serve to fuse the vertebræ together by a true osseous anchylosis, while in other cases they may give support to the part by merely becoming locked together. These masses of new bone are seen most often about the sides of the vertebral bodies, and appear sometimes as if derived from the anterior common ligament.

When the loss of substance is limited to a mere surface-erosion on the bone, the deficiency is supplied by a fibrous formation, although in some very rare cases, Follin and Duplay assert that the excavation may be covered in by a plate of new bone formed from the adjacent sound bone and periosteum.[1]

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[1] Op. cit., tome iii. p. 666.

Where the intervertebral disks are alone destroyed, and in some cases where the loss of bone is very limited, the vertebræ on either side of the gap may become fused together by a true, central, bony anchylosis, in addition, possibly, to union by bony processes at their periphery. M. Michel[1] alludes to a case where the fibro-cartilages between all the lower cervical vertebræ had been lost, and where the bodies concerned had become welded together by firm, but irregular, new bone.

If sequestra have formed they may be eliminated, or if they remain *in situ* they will be usually encysted and hidden from view. The tissue that incloses them may be either fibrous or bony, although it more usually belongs to the softer structure. Cloquet[2] records a case in which the last two dorsal and two upper lumbar vertebræ were necrosed, apparently *en masse*, but in which the entire sequestra were firmly inclosed in a solid, fusiform cyst of bone. By this means the solidity of the spine had been maintained.

Lastly, it must be remembered that the longer the disease has lasted, the less can the vertebral column look to the spinal muscles for support. From long continued disuse these muscles waste, and become degenerate, and by their feebleness add an additional source of weakness to the already debilitated column.

SYMPTOMS OF POTT'S DISEASE.—The symptoms of Pott's disease of the spine vary considerably, both in their comparative frequency and in their intenseness. They vary also in the order and time of their appearance, and will obviously be influenced by the locality of the mischief in the column. They can be most conveniently considered under the following distinct heads: (1) Rigidity of the spine. (2) Local pain. (3) The spinal deformity. (4) The abscess. (5) The cord and nerve symptoms. (6) The gait and general aspect. (7) Some general symptoms.

(1) *Rigidity of the Spine.*—A rigidity of that part of the vertebral column which is the seat of the disease is usually the earliest sign of Pott's malady, and is, apart from this fact, a feature of great importance. This rigidity is, when of early occurrence, due to contraction of the muscles of the back, and is nature's mode of endeavoring to keep the inflamed parts at rest. It is exactly to be compared to that rigidity of inflamed joints that is to be especially observed when disease commences in the articular ends of the bones. At a later period of the vertebral disease, this symptom is also due to the permanent rigidity of the posterior segments of the spine, and to those various conditions that lead to a false or true anchylosis of the diseased portion of the column. In advanced cases, where the muscles have become flaccid and atrophied, this latter condition is probably the sole cause of the symptom. To fully appreciate this early evidence of spinal caries, it is well to make one's self familiar with the degree of mobility permitted in the normal column in children and adults of various ages. In examining a young child, it is most convenient to have it placed flat upon its face, and then, on lifting up the lower limbs and moving them (together with the pelvis) in various directions, with the unoccupied hand placed upon the back, any rigidity of the column can be soon estimated. In Pott's malady, the portion of the spine which is the seat of the disease, appears to move in a piece, and will permit of little or no bending or rotation in any direction. In adults this feature can be investigated in the same manner, if an assistant moves the lower limbs and pelvis, and also by making the patient stoop and lean first to the one side and then to the other, or attempt any series of movements that will test the mobility of the spinal column.

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[1] Loc. cit., p. 478.

[2] Gaz. des Hôp., 1858, p. 108.

(2) *Local Pain.*—The symptom of pain, localized at the seat of disease, is of very uncertain occurrence, and is, perhaps, more often absent than present. For diagnostic purposes it is of no value. On this point, Mr. Fisher well observes that "local pain in the back is much more frequently met with when no disease of the spine exists than when the vertebræ are affected."[1] In many cases no pain is complained of in the back, at the seat of disease, throughout the whole course of the ailment, and in other instances it is scarcely severe enough to draw comment from the patient. This local pain, when present, is usually deep seated, dull, uncertain in its duration, and worse at night and on vigorous movement. It is often much aggravated by any motion that jars the spine, and may be found to be made worse when the spine is percussed. Mr. Howard Marsh, speaking of this symptom, says that the pain may be felt either at the affected spot or below it, but very rarely above it.[2] The pain, when present, is usually most obvious at the earlier stages of the disease, and ceases to be noticed when the spinal column has become more consolidated. It was the custom in less recent times to attach much importance to this local pain, and its recognition was accomplished in doubtful cases by pressing a hot sponge along the spine. This method of investigation has, however, been long proved to be useless. The pain to which reference is now made is due to inflammation of the bones, and proceeds, probably, directly from those tissues. It must be clearly distinguished from the severe, paroxysmal, and often agonizing pain that sometimes radiates from the back, and is due to some nerve-irritation.

In some cases, where the mischief is acute, there may be swelling and heat about the affected part of the spine. Such symptoms, however, are extremely uncommon.

(3) *The Spinal Deformity.*—This deformity, the so-called "angular curvature," is the most conspicuous symptom in Pott's disease. The method by which it is produced has been already detailed in the paragraph on the pathology of the disease. In many cases it is the first symptom noticed; and, indeed, in hospital practice it is unusual for a patient to be brought for treatment at a stage of the disease antecedent to the occurrence of the deformity. The deformity makes itself evident at an earlier period in some parts of the spine than it does in others, and the conspicuousness of the "curvature" is greatly influenced by its site.

The deviation of the column is seen earliest when the dorsal region is attacked, the explanation being that the dorsal spine has already a normal curvature backwards. The spinous processes also, in this region, are of great length, and are soon rendered prominent by being separated somewhat from one another. In the lumbar region the deformity is very slow to appear, owing to the fact that the normal curve in this part of the column is directly forwards; and, moreover, there must be considerable destruction of the vertebral bodies before it can make itself evident. In the cervical region no regular deformity is produced. In this region the muscles are better able to support and balance the diseased segments, with the result that, as the destructive process advances, the head simply subsides vertically towards the trunk, and the column becomes shortened. In some cases—either from unequal destruction of the bones, or from unusual muscular action—the cervical spine acquires a slight lateral deviation to one or other side. In any case, the marked rigidity of the column is very conspicuous.

It will thus be seen that the deformity in Pott's disease will be most conspicuous, and will reach its greatest degree of development, when situate in

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[1] Op. cit., p. 12.

[2] British Medical Journal, vol. i. p. 913. 1881.

the dorsal region. It must not be supposed, however, that an "angular curvature" of necessity appears in all cases of Pott's disease below the cervical region. In some cases—especially in lumbar disease—no deformity appears throughout the whole progress of the malady; but at the same time it must be confessed, that the absence of distortion in dorsal disease is very unusual. Bouvier endeavored to construct a table to show the relative frequency of deformity in the various segments of the spine, with the following results:—[1]

Out of 101 instances of Pott's disease there were

10	cases of	lower cervical	disease,	3	with deformity,	7	with none.
55	"	dorsal	"	45	"	10	"
36	"	lumbar	"	20	"	16	"

These statistics are, however, of but slight value, inasmuch as the duration of the disease is not given in the various cases. And it may not be unreasonable to suggest that in some of the cases credited with no deformity, an "angular curvature" may have in time developed.

The deformity itself consists in a bending backwards of the column in the antero-posterior plane of the body, and its great feature is this: it is *angular* and *median*. The extent and prominence of the "curvature" will depend not only upon the seat of the mischief, but upon the amount of bone lost in the anterior segments. A sharp and abrupt angle will usually indicate a severe but limited loss of bony tissue, while a more extensive and more rounded deformity will probably indicate a slight degree of destruction of many vertebræ. In some cases the bending of the column may be so severe that the two parts of the spine form a right angle with one another, or the anterior surface of the vertebra above the excavation may rest on the upper surface of the vertebra below it. When the disease is of long standing, the prominence of the deformity may be increased by the wasting that occurs in the muscles of the back. In certain cases there may be some slight lateral deviation of the spine in addition to the antero-posterior displacement. This condition would appear to be met with only in the lumbar and dorso-lumbar regions, and is due either to unequal destruction of the vertebræ, or to unusual muscular action. In all cases compensatory curves are formed both above and below the seat of the deformity. It is only by means of such compensation that the patient can retain the erect posture. These curves are best seen when the disease is situate in the dorsal spine, and will obviously vary in degree according to the extent of the original deformity. In some cases of Pott's malady involving the lumbar region, where the destruction of the bodies has been sudden and severe, no compensation is possible: the erect posture cannot be maintained, the column falls forwards, and the patient can only progress when upon his hands and feet, or knees.

In nearly all instances the deformity develops slowly, but cases have been recorded in which the "angular curvature" appeared with comparative suddenness. In such cases—of which Michel gives examples—the deformity has usually appeared during some unwonted or forced movement, and has been due to a giving way of some of the supports furnished to the diseased parts, or to fracture of the posterior segments of the column at the seat of caries. Delpech, Nélaton, and Louis all record instances where this sudden formation of the "curve" has been associated with sudden paraplegia. The rapidity with which the deformity develops depends to some extent upon the patient's movements, and upon the non-observance of rest. Shaw,[2] however, records a case where no increase of the spinal deviation occurred during a period of fourteen years, although the patient was engaged all the while in the work of a blacksmith. At the end of the period mentioned, an abscess appeared. Like examples have been put on record by others. It is important also to note that the deformity may commence and may increase while the horizontal position is being observed. Such cases show that the weight of the column above the seat of disease is by no means the only factor in producing the angular deviation, but that the abdominal muscles may also be active agents in that direction.

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[1] Quoted by Michel, loc. cit.

[2] Loc. cit., page 114.

(4) *The Abscess.*—The chief points in connection with this symptom have already been dealt with in considering the pathology of the disease; and some further facts will be noted in dealing with the matter of diagnosis. So variable is the evolution of the symptoms of Pott's disease, that the spinal abscess may be the very first evidence of the malady, and, on the other hand, this affection may run its entire course, and end in anchylosis and cure, without any trace of abscess having been observed.

The absence of abscess is, however, quite the exception. As to the period of the disease at which this symptom should become evident, nothing positive can be said. It may appear before any deformity is obvious; it may be the very earliest symptom; it may not appear until the disease has existed for many years. Many cases are recorded where the abscess did not appear for ten, fifteen, twenty, or more years after the commencement of the disease, the patient having in the mean time apparently made a perfect recovery. It is probable that all such cases are examples of what Sir James Paget[1] has called "residual abscess," that is to say, an abscess taking its origin from the residues or relicts of past suppuration. The patient has caries of certain vertebræ, and an abscess is formed at the seat of disease, but does not tend to reach the surface of the body. In time a process of cure takes place, the wall of the abscess shrinks, its contents become more or less absorbed, and perhaps no trace is left but some small collection of caseous matter. As long as the patient's health remains good, and as long as no injury or unusual circumstance tends to irritate the part, so long does this residuum of a past inflammation remain inert. But when these untoward conditions are provided, the ill-disposed material acts as an injurious foreign body, and an abscess that perhaps reaches the surface is the result.

As to the influence of local and general conditions upon the formation of the abscess, something a little more definite can be said. As may be surmised, the more acute and rapid is the spinal mischief, the more certain and the earlier is an abscess likely to appear. Moreover, a general condition of ill-health is apt to affect the formation of the abscess in a like injurious manner. The same may be said of neglect of treatment, of persistence in movement and exercise, and of direct injury to the diseased parts. In opposition to these general statements, however, numerous exceptions have been recorded. Mr. Fisher mentions the case of a gentleman who had presented a projection of the spine for more than two years, no abscess appearing until the end of that period, although the patient had during the whole time indulged in the usual athletic pursuits of young men. Then again, an abscess may be associated with a form of Pott's disease that has assumed a very chronic course, has given little or no trouble, and has led to but trifling deformity. On the other hand, instances are recorded of an absence of external abscess, though the disease is accompanied with severe deformity and paraplegia.

The general features of the abscesses that accompany Pott's malady are identical with those of cold abscess in general, and require no especial description. Lannelongue[2] has shown that the surface-temperature over these collections is higher than that of the corresponding surface on the other side of the body. He quotes the case of a child, aged 7½ years, with a lumbar deformity and a large psoas abscess at the upper part of the left thigh. This abscess showed an absolute absence of any of the common signs of inflammation, and was indeed a typical cold abscess, yet the temperature noted was as follows:—

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[1] Clinical Lectures and Essays. London, 1877.

[2] Loc. cit., page 171.

	On one occasion.	On another occasion.
Temperature in axilla, ...	37°.6 (99°.7 F.)	37°.5 (99°.5 F.)
Surface temperature of thigh on healthy side,	37°.0 (98°.6 F.)	36°.5 (97°.7 F.)
Surface temperature of thigh over abscess,	37°.2 (99°.0 F.)	37°.1 (98°.8 F.)

Lannelongue has also shown that this feature in the temperature applies to all cold abscesses.

(5) *The Symptoms depending upon Implication of the Spinal Cord and Spinal Nerves.*—Considering, on the one hand, the position of the spinal cord and nerves, and, on the other, the great deformity in the column and the great destruction of parts often produced by Pott's disease, it is no matter of wonder that these delicate nerve-structures sometimes suffer injury. They are, however, by no means constantly involved. The frequent immunity of the cord in Pott's malady is, to some extent, to be explained by the fact that the cord occupies the posterior portion of the vertebral column, a part not only as a rule exempt from destructive disease, but the seat actually of extensive reparative changes. It also must be borne in mind that the changes in the column are of such a nature as to cause the inflammatory products to take a forward direction, while the development of the deformity is usually so slow that the cord has time, as it were, to accommodate itself to the change. And it is marvellous to what changes the cord will accommodate itself, if only the morbid influences around it are slow in their action. In any case of Pott's disease with severe deformity, the cord must not only be abruptly bent, and compelled, possibly, to occupy a much more limited space than in the normal condition, but it would appear that in some instances it must be actually shortened. Still, it is common to have examples of severe spinal deformity without nervous symptoms of any kind.

Roughly speaking, the symptoms that are now to be detailed may be ascribed either to irritation of the spinal cord and nerves, or to such an injury to those parts as may cause temporary or permanent interruption of their functions. Thus, there may be, on the one hand, severe pain or hyperæsthesia, and on the other, loss of sensation. And as regards the motor tracts, there may be muscular spasms and increased reflex action in one instance, and absolute paralysis of certain parts in another.

The post-mortem examination of patients with Pott's disease, who have exhibited nerve-symptoms during life, will give very various results. In some cases, the meninges of the cord will be found much thickened at the seat of disease, or, in other instances, a considerable inflammatory exudation will exist between those membranes and the spinal wall, and intimate adhesions may be found between those parts. As regards the cord itself, it may be congested, or inflamed, or the seat of a definite sclerosis. In many cases it will show some limited softening, that, while of very varying extent, will be found most usually to involve the motor regions of the cord. Injurious pressure will be found in most instances to be the cause of these conditions, and especially of the condition of softening in the medulla spinalis. The pressure may be effected by the abrupt bending of the spine, or be caused by detached vertebræ, or displaced fragments of bone; or it may be due to the bulging of inflammatory products toward the spinal canal, or to the undue prominence in the same direction of new bone formations. As regards the spinal nerves, they are liable to become inflamed on account of their proximity to the seat of disease. They are liable to irritation from the near presence of fragments of bone, or displaced portions of the column. They are susceptible, also, to varying degrees of injury from pressure. When many vertebræ are lost, the corresponding intervertebral foramina are usually more or less involved, and in such instances Michel observes that it is common for many successive spinal nerves to issue from one huge and irregular intervertebral foramen produced by the disease.

It is extremely difficult to say in what cases cord and nerve symptoms are to be expected, and in what cases they are not apt to occur. They may appear early in quite slight cases, or they may be entirely absent in the most severe examples of the disease.

As to the relation between the cord-symptoms and the local condition in the vertebral column, these few points can alone be mentioned: Cord-symptoms are more apt to occur in cases where the disease progresses rapidly, and the deformity is sooner produced than in cases where the opposite conditions obtain. Cord-symptoms are more apt to occur in cases associated with deformity than in those unattended with deviation of the column. According to Bouvier's statistics on this point, out of 64 cases of Pott's disease with deformity, paralysis occurred in 33 instances; whereas only 8 examples of paralysis were met with in 32 cases of the disease unassociated with deformity. Allowing for many exceptions, cord-symptoms are more apt to occur in severe forms of the disease, in cases associated with much muscular weakness, in cases where undue movement has been allowed or no treatment adopted, and in cases where accident has suddenly added to the extent of the deformity.

The various symptoms may most conveniently be considered under two heads—first, disturbances of sensation, and secondly, disturbances of the motor system.

Disturbances of Sensation.—Pain transmitted along a certain nerve or nerves is very often the first symptom of disturbance of the great nerve-structures. This pain is probably due to irritation of some of the spinal nerves as they issue from the intervertebral foramina, although it may in some cases be due to a disturbance in the medulla spinalis itself. The seat of the pain varies—as Mr. Howard Marsh has well pointed out—with the locality of the bone-mischief. In caries of the lower cervical region, the pain is apt to radiate over the shoulders and down the arms, or over the upper part of the front of the chest. In dorsal disease, the pain follows the intercostal nerves, and may be felt at the sides, or in front of the trunk, about the middle line. When the malady attacks the lumbar spine, the pain tends to radiate about the loins and pelvis, or to run down the limbs and to extend even to the feet.[1] The characters of this pain are tolerably distinctive. It is sometimes severe, usually sharp and paroxysmal, rather than continuous. It is indeed a neuralgic pain.

It is often limited to one side of the body, or even to one nerve. For example, in cases of dorsal disease, intercostal neuralgia of a single space is by no means uncommon. The pain may be associated with hyperæsthesia of the part supplied by the affected nerve, or of a part supplied by some adjacent trunk. But such a complication is not common. The pain is very usually made worse by exercise and violent movement, and a sudden jarring of the column may render it, for the moment, almost agonizing; on the other hand, the patient is easier when in the recumbent posture, and often the painful sensation will entirely disappear when a little extension is applied to the column.

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[1] The Diagnosis of Caries of the Spine in the Stage preceding Angular Curvature. British Medical Journal, vol. i. page 913. 1881.

This "nerve-pain" is very different from the dull, deep-seated, and well-localized pain already spoken of in a previous paragraph. The latter is a "bone-pain," is worse at night, is perhaps modified by the weather, and, if increased on movement, is increased to no severe extent. The one depends upon the irritation of a nerve-trunk, the other upon actual disease in the bone, augmented by the mutual pressure of the parts.

In some instances, the patient may complain of a painful sensation about the body, as of a cord tied around it, about the level of the epigastrium or umbilicus. This sensation may be an extremely painful one, and may, according to some French authors, be very like the pain of a linear burn. The symptom, although common in many affections of the cord, is certainly extremely rare in Pott's disease, as Mr. Marsh has recently pointed out. The same writer has also drawn attention to the fact that the pain when located about the abdomen, may be readily the cause of a faulty diagnosis. He records the case of a child, aged five, who suffered from a pain in the stomach supposed to be due to indigestion, for which, indeed, she was treated for some weeks. The pain was in reality due to disease in the mid-dorsal vertebræ, and could have been distinguished from the pain of indigestion by the fact that it was not worse after meals, that it was increased by vigorous movement, and relieved by recumbency. The "lightning" pains that are so common in certain diseases of the cord are not met with in Pott's malady, although tingling sensations may be felt in parts, or a discomfort described as "pricking pains."

Lastly, there may be a loss of sensation in parts below the seat of the vertebral disease. This anæsthesia is quite uncommon, and never occurs alone, but when present is always associated with loss of motion, which, in nearly every instance, will be found to have preceded it, and to be of a more extensive character. It is rare for the loss of sensation to be absolute. Usually there is only a sense of numbness, or an anæsthesia of a comparatively limited district. The instances of complete loss of all sensation below the seat of disease are very few, and have in all examples been associated with absolute paraplegia.

Disturbances of the Motor Nervous System.—These disturbances may be classed under two heads: (*a*) Those marked by nerve-irritation, convulsions, spasms, etc.; (*b*) those marked by loss of nerve-function, or palsies.

(*a*) These disturbances may assume a variety of aspects. In the least marked instances, there may be simply undue reflex irritability. In such cases, on touching or gently tickling the sole of the foot, the limb is violently drawn up, or movements may be induced in it by equally trifling irritation. In other cases this morbid condition of the nerve-centre may express itself in an involuntary jactitation of the limbs, that may be brought about by very slight peripheral disturbances.

In severe grades of this condition, the limbs below the seat of the vertebral disease may exhibit spasmodic or convulsive movements. These spasms may sometimes be very violent, and associated with considerable pain. They may occur spontaneously, but can be induced or rendered more vigorous by irritating the periphery, as by tickling the feet or pinching the skin, etc. These symptoms are practically limited to the muscles of the lower limbs, and to the abdominal and sacro-lumbar muscles. Only one limb may be affected, or only one muscle or set of muscles in that limb, and when both sides of the body exhibit these spasmodic attacks, the symptoms are usually more marked on one side than on the other.

In other instances the spasm may be continuous, and the legs may remain rigidly drawn up. This form of contraction may be associated with much pain, may be of limited or unequal extent, and may alternate or be associated with the intermittent or clonic spasm just referred to. The condition is generally known as "spastic contraction," and is perhaps somewhat more frequent than is the condition marked by interrupted spasm. So rigid may the patient's body become in some cases where the muscles of the lower limb and back are the seat of continuous muscular contraction, that, according to Shaw, he may be turned over in bed like a log.

Among the peculiar phases of motor-nerve disturbance in Pott's disease may be mentioned torticollis, observed in some cases of caries of the cervical spine, and also a severe and intermittent form of dyspnœa, occasionally met with in caries of the same situation, and due, according to Michel, to irritation, or perhaps paralysis, of the phrenic nerve.

(*b*) *Palsies.*—The usual form of motor paralysis observed in angular deformity is paraplegia. This may be complete, and equally marked in the two lower limbs. It usually develops slowly, although cases are recorded of sudden paraplegia in connection with the sudden appearance of the spinal deformity. The loss of motor power may be more marked in one extremity than in another, or may be limited, more or less, to one particular set of muscles. In other instances there may be mere feebleness in the part, which feebleness may, like the more complete losses of power, be of limited or unequal extent. It is probable that many of the cases of marked paralysis of a limited set of muscles are due to pressure upon the spinal nerves rather than to an injury to the cord itself. With reference to the previous symptoms, the order adopted in their development is usually as follows: First, involuntary jactitation of the limbs, then constant muscular spasm, and, lastly, paralysis. Often, however, the loss of power is preceded by no evidences of spasm. The paraplegia in Pott's malady has certain peculiarities. It is very usually unassociated with any loss of sensation, or allied with but trifling disturbances of that function. It is, moreover, very seldom accompanied by loss of control over the bladder or rectum, and when such a complication is present, it is usually but slightly marked, and often preceded by a painful tenesmus. In incomplete palsies the muscular sense remains unimpaired. On account of the comparative rarity of defects in sensation, bed-sores are as unusual in Pott's disease as they are common in other forms of paraplegia. Lastly, this form of loss of power may be entirely recovered from, as will be mentioned when the matter of prognosis is discussed. The reaction of the paralyzed muscles to electricity remains normal, unless the condition is of such long standing that the muscular tissue has become disorganized.

The convulsive movements already referred to may sometimes be observed in the paralyzed limbs, and when present constitute a very distinctive feature. They can only occur in cases that are comparatively recent, and will obviously not be possible when the muscular structure has become much changed from prolonged disease.

(6) *The Gait and General Aspect.*—In marked cases of the disease, the patient in walking keeps the spine peculiarly rigid. He walks with his legs only, often shuffling the feet along, and swaying the body to and fro. His movements, therefore, are stiff and ungraceful. When asked to pick up an object from the ground, instead of bending the back, he bends the lower limbs, and approaches the object sideways, as it were. This attitude is well shown in drawings in Prof. Agnew's article on Surgical Diagnosis.[1]

In cases where the deformity is marked, the patient stands with the head thrown back, and often supports himself by resting his hands upon the thighs. If one side of the column be more affected than the other, the patient is disposed to lean the body towards the less affected side. When in the recumbent posture, the patient prefers to lie upon his side, and when moving from that position to the sitting posture, he effects the movement by turning over on to his belly, and then raises himself by his hands and knees. As a consequence of the angular deviation of the column, the whole trunk appears shortened and out of proportion to the extremities. The antero-posterior diameter is increased, and the sternum protrudes. In severe disease of the dorsal spine this protrusion of the sternum may be considerable. The ribs are often rendered more or less rigid, not only by the constrained position induced by the spinal and thoracic deformity, but often also by destruction or anchylosis of the costo-vertebral joints. Lastly, the shoulders appear to be raised, and the head and neck to be more or less sunken towards the thorax. One feature that has been particularly alluded to by Sayre, is the short, "grunting" respiration often observed in cases of dorsal disease with much deformity both of chest and spine. Dr. Sayre asserts that this symptom is often immediately relieved when the patient is suspended.

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[1] See Vol. I., page 344, Figs. 21 and 22.

(7) *General Symptoms.*—Of the general symptoms that may accompany Pott's disease, little need be said. The patient may or may not present evidence of struma, or be afflicted with any concomitant scrofulous disease. Seldom will the subject of the malady present the appearance of actual good health. When external discharge of matter is accomplished, there will probably be a rise of temperature, some wasting, and increasing debility, with all the familiar symptoms of hectic fever. If the suppuration be of long standing, symptoms may arise that point to amyloid or fatty degeneration of the viscera. At any time there may be certain visceral complications of a less chronic character, more or less directly connected with the seat of the disease. With regard, indeed, to any general symptoms that have not been mentioned, they may be said to be such only as are incidental to all conditions of feeble health, and to all states of extensive and continued suppuration.

DIAGNOSIS OF POTT'S DISEASE.—The main points upon which the diagnosis of Pott's disease is to be based, have been exposed in the preceding pages. It remains, however, to discuss the differential diagnosis, and to set forth the means whereby this malady may be distinguished from such diseases as, in certain features, may have resemblance to it. The matter can be best considered under the three heads: The spinal deformity; the cord and nerve symptoms; the abscess.

(1) *The Spinal Deformity.*—The great features of the spinal deviation in Pott's disease are its angularity, its median position, and its general rigidity.

In *cyphosis* there is a bending backwards of the spine, but in this condition the deformity assumes the outline of a curve that usually involves in an equal degree a large portion of the column. There is in the first instance no rigidity, and, except in cases of spondylitis deformans, at no time absolute or complete rigidity.

Cases of Pott's disease, where a deformity exists associated with some lateral deviation of the column, but, at the same time, with an absence of any more familiar evidences of the malady, may possibly be mistaken for *lateral curvature.* Shaw gives an instance in illustration of this. He says that he "was consulted about a girl, aged fifteen, who had a projection at the dorso-lumbar region, with a distinctly marked deviation of the spine to one side, simulating closely lateral curvature. The medical attendant had considered the case to be of that kind, and had put the patient on a course of calisthenic exercises. It was distinctly ascertained, however, that the prominence was the effect of caries; and the principal diagnostic sign was the directness with which the spinous processes stood out backwardly against the skin; for it is a never-failing observation in regard to lateral distortion, that, owing to the rotation of the column on its long axis, which always accompanies incurvation, the spinous processes are pointed laterally, towards the concavity; and that to such a degree that they are nearly hidden from view by the overlapping of the edge of the longissimus dorsi."[1]

Aneurisms of the abdominal and thoracic aorta may cause such an erosion of the spine as to lead to the angular deformity of Pott's disease. If the destruction of bone be still more extensive, nerve-symptoms are produced from pressure, that may have the characters of those met with in caries, and that may go on even to paraplegia.[2] In such cases the distinctive symptoms of aneurism would be present, and the diagnosis patent. At the same time, it must be noted that these aneurisms occur usually at a time of life when spinal caries is very rarely met with.

Michel refers to a case recorded by Mazet, where during life there was an "angular curvature" of the column, and near it a large fluctuating tumor like a chronic abscess. It, however, proved to be a *hydatid cyst* growing from the vertebral canal.

(2) *The Cord and Nerve Symptoms.*—In cases where the characteristic deformity exists, there can be no difficulty in diagnosing these symptoms; or in any case at least where such symptoms coexisted with "angular curve," it would be safe to ascribe the former to the same disease that had caused the latter.

The most difficult cases of Pott's malady to recognize are those associated with no deformity. In some such cases, a psoas or lumbar abscess may exist and assist the diagnosis, but when that symptom is absent, an opinion has to be based to a great extent upon such nervous disturbances as may be present. In these cases, without deformity, the spine will be found to be more or less rigid in one part; there may be local pain, increased on exercise and relieved by extension; and there may be some peculiarity in the patient's gait and movements. If any symptoms of nerve or cord disturbance exist, they may be of great value, and it is now necessary to point out with what other conditions those symptoms may be confused. In "*hysteria of the spine*," the patient may complain of severe pain about some part of the column, of inability to move the back or to maintain the erect posture without great suffering, and possibly of radiating pains along certain nerves, such as the intercostal. The pain may be localized about the vertebra prominens, and the normal projection of this vertebra may lay the foundation for the assertion that the "spine is growing out." If the patient has taken to her bed—as is not infrequently the case—under the impression that she has severe spinal mischief, the spinous processes of many vertebræ may in time appear unduly prominent, from atrophy of the muscles from disuse. If the case be associated with "hysterical paraplegia," a fresh complication is introduced. In these examples of simulated disease, however, there will generally be distinct evidences of hysteria, an absence of any real angular deformity, and no rigidity of the affected part. The pain, moreover, will be of that limited and agonizing character common in hysterical neuralgia. Lastly, when the spine is being examined, the patient will probably wince and jerk the back away every time that the column is touched, a manœuvre that would certainly not be executed if the tenderness depended upon caries.

In cases of *muscular rheumatism* of the back, there may be much local pain and a good deal of rigidity of the part. Such cases, however, may be distinguished from those of Pott's disease by the following features. The rheumatic pain is diffused, and follows no particular nerve; the pain is increased rather than relieved by extension; the parts are tender often over a wide area; and the disease is more common at an age when Pott's disease is rare. There will, probably, be in addition a history of rheumatic affections.

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[1] Loc. cit., page 111.

[2] Quincke, Diseases of Arteries; Ziemssen's Cyclopædia of Medicine, vol. vi. p. 434.

Cases of commencing *hip-disease* in children have been mistaken for an early stage of Pott's malady. Children so afflicted often cry if moved much; keep the spine, pelvis, and hip-joints as rigid as possible; are disinclined for any exercise; and often complain of vague pains that may not be very accurately localized. A little care in the examination of doubtful cases, however, will soon eliminate the instances of hip-mischief. *Infantile paralysis* may in some way imitate the paraplegia of Pott's disease, from which it can, however, be distinguished by the history of the case, the atrophy of the affected muscles, and the absence of any rigidity or any pain about the spine. Follin and Duplay assert that muscular weakness associated with *rickets* may resemble the loss of power sometimes met with in Pott's malady, but it is difficult to appreciate the grounds of such resemblance, or to imagine that it could be so close as to cause confusion in diagnosis. One author reaches the extreme limit of doubtful refinement in diagnosis, when he points out how Pott's malady without deformity is to be distinguished from *chronic nephritis.*

(3) *The Abscess.*—The differential diagnosis of abscess from spinal disease appearing in various regions, can only be given in the merest outline.

Abscesses in the lumbar or iliac regions must be distinguished from simple chronic abscesses, from perinephritic and pericæcal abscesses, from abscesses due to disease of the ilium, and from certain fluctuating renal tumors. In the *simple chronic abscess*, the symptoms will be purely negative. In the *perinephritic and pericæcal abscesses*, there will probably be evidence of some disturbance of the viscera about which the pus has formed, and an absence of all the local signs of Pott's disease. The latter abscess is met with only on the right side of the body, and the pus it discharges is usually of feculent odor. It must also be remembered that pus from spinal caries may occupy the connective tissue about the kidney or cæcum. *Caries or necrosis of the ilium* can in the early stages be little more than suspected, and the symptoms of abscess will advance without any evidence of Pott's malady appearing. The *fluctuating renal tumor* may be hydatid, cystic, or cancerous, or due to distension of the kidney with urine or pus.

With regard to the inguinal region, it is here that the typical psoas abscess is met with. In this abscess there will be a smooth, round, fluctuating swelling below the groin, and about the site of the ilio-psoas insertion. There will probably be a second collection to be felt in the iliac region above the groin. The collection in the thigh can be more or less reduced on pressure, and will present a distinct impulse on coughing or on tapping the iliac tumor. In some instances the communication between the iliac and inguinal collections may be for a time cut off, when the lower tumor will present simply the features of a chronic abscess. Psoas abscess in the groin may be mistaken for abscess from *hip-disease*, but in the latter instance there will be more or less rigidity of the joint in a flexed and adducted posture, with tilting up of the pelvis on the diseased side. The spine will be in a condition of lordosis, and often unduly mobile. There will be no impulse at the collection on coughing, and the other evidences of hip-mischief will probably be present. Cases are recorded where the spinal abscess has been mistaken for a *femoral hernia.* Shaw gives an excellent example of such a case where a truss was actually ordered. The psoas abscess is, however, nearly always to the outer side of the femoral vessels, and, on examination, the femoral canal will be found to be clear. The hernia, if reducible, is returned with a peculiar gurgle, and is of slow formation. If of any size, it will also be, as a rule, tympanitic on percussion. The following case—recorded by Shaw[1]—will show how closely a *cancerous tumor* about the groin may imitate a spinal abscess. He had under his care "a female, of middle age, who had lateral curvature of the spine from girlhood; and in whom the hump was so prominent and abrupt, that it might be mistaken for angular deformity from caries of the vertebræ. She was admitted for a tumor that occupied the inner side of the left wing of the pelvis, and was on a level, at its anterior part, with the crest of the ilium. An oval-shaped, projecting lobe, in course of time formed on its most dependent face, near Poupart's ligament; and the feeling communicated to the finger, when examining that part, bore the greatest resemblance to what is conveyed by pus, when near the surface of an abscess. The subsequent progress and termination of the case showed that the tumor was one of medullary cancer." Among *other tumors* in the inguinal region that may possibly be confused with spinal abscess, are bubo; varix of the saphenous vein; fatty, cystic, and other soft or fluctuating tumors; and possibly some cases of aneurism.

Before concluding the matter of diagnosis, it is to be observed that it is scarcely possible to diagnose with any certainty the *nature* of the bone-mischief during life. In less recent times, much was written on the distinctions between simple and tubercular caries, and on this point the arrangement of Broca was perhaps the most popular. He asserted that tubercular osteitis occurred in children, and, as a rule, in the cervical and dorsal regions, and that it soon led to deformity, and to paraplegia. Whereas simple caries appeared usually in adults, and in the lumbar spine, and was marked by a very tardy deformity and no paralytic symptoms. This arrangement is very fascinating, but must, in the present state of our knowledge, be, I think, discarded as useless.

PROGRESS, PROGNOSIS, ETC.—The *progress* of the disease is, as a rule, slow. In some cases it may be so slow, and produce so few symptoms, that the malady is hardly noticed by the patient. Thus cases are recorded where the patient followed a laborious employment during the development of the disease, and where years elapsed before any troublesome symptoms—such as abscess or cord-troubles—appeared. There are cases, on the contrary, where the malady has been acute, and has pursued a rapid course. But, as a rule, even these acute cases are not acute from the first. They begin as chronic maladies, and then, for some particular reason, take on an acute action. The great feature, however, in the progress of Pott's disease is its uncertainty. Seldom is its progress uniform, but marked rather by the utmost variety, not only in the rate at which it advances, but also in the period at which certain symptoms appear, and in the general features of those symptoms themselves. The actual time, therefore, occupied by the disease must vary considerably. Except in very few instances, it can hardly run its course in less than six or nine months, although Michel asserts that the period of time from the commencement to the termination of the malady may be as little as three months. In the majority of cases, the duration of the active disease is to be estimated by years, and not by months, and perhaps one or two years would be an average time for the period occupied by the course of the disease. It would be difficult, perhaps impossible, to detail the circumstances that influence the rate of progress of spinal caries. It may be, here, only necessary to observe that the malady, as a rule, advances more rapidly in adults than it does in children, and in the cachectic and ill-nourished than in those originally robust. It must be understood that the disease is considered to end when anchylosis has ensued, and at any time, of course, the period of the disease may be terminated by death. In cases of cure, the deformity still persists, and patients may live a lifetime with all the outward signs of Pott's malady, and yet enjoy good, or at least fair, health.

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[1] Loc. cit., page 126.

The *prognosis* with regard to the *deformity* is therefore very distinct. The lost parts of the vertebral column are never restored, and the deformity never disappears. With regard to the *abscess*, perfect cure may be brought about without the appearance of any purulent collection; or the pus may remain stationary for an indefinite time, and then either entirely disappear or discharge itself from the surface. The usual course, however, is for an abscess to form that comes in time to the surface, and then discharges itself, and this particularly applies to cases of Pott's disease in adults. When the abscess has opened, and has discharged for a considerable period, cure may still follow; the sinuses may close, the discharge cease, and the spine consolidate. This fortunate result would appear to be most usual when the abscess opens close to the seat of the disease. Michel[1] has collected 22 examples of cure following upon the natural or artificial evacuation of the abscess. Of these abscesses 8 were psoas, 1 appeared at the sciatic notch, 1 in the perineum, and 12 in the dorso-lumbar region. As already observed, a residual abscess may appear at almost any time, and in any case of Pott's malady that has undergone cure, or what is practically a cure.

The *paraplegia* in Pott's malady may persist, but at the same time it is not infrequently recovered from. The recovery may be complete and permanent, or it may be only partial, and a certain set or sets of muscles may remain absolutely paralyzed, or the patient may always present some feebleness in the whole series of muscles that have been affected. Cases of recovery are recorded in quite severe examples of paraplegia. Thus Dr. Sowers reports an instance in a little girl aged 8½ years, whose lower limbs were entirely paralyzed, and who in addition had some loss of power in both upper extremities, and also in the bladder. She made a complete recovery. As may be supposed, the prognosis is much more favorable in children than in adults. More than one attack of paralysis may be recovered from. Thus Shaw quotes the case of a boy, aged six, who had two attacks of paraplegia in two years. He recovered perfectly from both attacks. Nichels gives an account of a man, aged 24, who had three attacks of paraplegia in eight years.

It remains now to consider the prospects of *cure* in any case, and the causes of *death*. A cure is much more common in children than in adults, and in those cases associated with deformity than in those without. The following statistics given by Michel bear upon this point. In 33 fatal cases without deformity, 24 died of the disease itself, and 9 of some other disorder. In 68 fatal cases with deformity, 35 died of the disease itself, and 33 from some other cause.

The extent of the disease has also to be considered, and the general state of the patient's health. The presence of abscess or of paraplegia will very materially lessen the prospects of cure; and paralysis in connection with cervical disease is peculiarly apt to end in death.

When death ensues, it is most commonly from the abscess. The patient dies of hectic, or of amyloid degeneration of the viscera, or of pyæmia, or of simple asthenia—worn out by excessive discharge—or indeed by any of those modes of death that result from long-continued suppuration. Very often a sudden change for the worse occurs in the patient's condition when the abscess is opened, and out of 28 cases reported by Michel, where the time of the evacuation of the abscess was known, death followed in 20 days in 10 instances. The same author also gives the following as the causes of death in 44 cases of spinal abscess.

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[1] Loc. cit., p. 493.

In 14 cases death resulted from tuberculosis of the lungs.
In 16 " " " " marasmus.
In 5 " " " " sloughing of the limbs from œdema.
In 4 " " " " pyæmia.
In 2 " " " " arachnitis.
In 2 " " " " pus in the medullary canal.
In 1 " " " " pneumonia.

In some cases the patient dies from extension of the mischief in the cord, or from actual inflammation of the cord or its membranes.

Any thoracic complication is apt to be dangerous in those cases of Pott's disease which are associated with deformed chest.

Among the less usual causes of death, may be mentioned hemorrhage, as in a case observed by Legouest,[1] where fatal bleeding occurred from the vertebral artery in an instance of cervical caries, and as in another case recorded by Fuller,[2] where the abdominal aorta was perforated. [The editor[3] has recorded a case of psoas abscess which ended fatally through hemorrhage from a branch of the internal iliac artery.] Death has also occurred from suffocation due to the sudden discharge of a spinal abscess into the bronchi, and from like unusual causes.

TREATMENT OF POTT'S DISEASE.—This may be considered under the heads of local and general treatment.

Local Treatment.—The treatment of the spine in Pott's disease has been for a considerable period a subject of dispute, and is still a matter upon which much difference of opinion exists. These differences involve, however, rather matters of detail than general principles, and it is more than probable that they will become still less conspicuous when our knowledge of the pathology of the disease is more distinct. The indications for local treatment are well expressed by Mr. Fisher, in his essay on this deformity. They are: "First, the obtaining a condition of immobility for the diseased bones; secondly, the relieving them from the pressure caused by the weight of the body above; thirdly, the relaxation of local muscular contraction; and, lastly, the restoring of the spine, as far as possible, to its normal condition."[4] With regard to this last indication, the term "normal" must be used in a very modified sense. A consolidation of the diseased part is the issue hoped for, and a rigidity of the region is desired, that obtains in no normal spine. Moreover, the removal of the deformity must always be a secondary consideration in treatment. Deformity of some amount is necessary for substantial cure, and no method of treatment can be more injurious than that proposed for the sole purpose of removing the disfigurement. Local treatment with this object is the usual expedient of the "bone-setter" who treats Pott's disease. He professes to recognize in the deformity a dislocation of the spine, and proceeds to restore the parts by violent extension, and by manipulation of a no more gentle character. Under such measures the posterior segments of the column, upon which the main hope of cure depends, have been broken across, and sudden paraplegia, or even death, has been the result. The indications just mentioned may be carried out by (1) the recumbent posture; (2) certain mechanical appliances; (3) a rigid jacket applied during extension of the column.

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[1] Gazette Hebdom., p. 76. 1861.

[2] Ibid., p. 524. 1859.

[3] Principles and Practice of Surgery, 3d ed., p. 662, Philadelphia, 1882.

[4] Op. cit., p. 18.

(1) Treatment by *prolonged recumbency* is of extreme value in Pott's disease. Indeed, considered in the abstract, or apart from certain difficulties and inconveniences, it is probably the very best treatment available for this malady. In the recumbent posture the spine is at rest, and the muscles relaxed, the evils of the pressure of the diseased surfaces against one another are minimized or removed, and the very least inducements are offered for the malady to progress. In all rapid and acute cases, this plan of treatment should be strictly carried out, and should be the only means adopted. In other cases it is well, under all circumstances, to commence the treatment by a period of enforced recumbency, and to allow this measure to be a preliminary to further treatment by instruments, jackets, etc. Many surgeons would, however, urge that recumbency should be the treatment of all forms of Pott's malady, and should constitute the only local measure. Without going as far as this, it must be regretted that this simple expedient is not more extensively and practically resorted to, and that more means are not afforded in hospitals for its employment. When this mode of treatment is adopted, the patient should be made to lie upon a firm, well-padded mattress, with the spine as straight as possible, and with the head, trunk, and limbs on the same plane. Any but slight and necessary movements must be forbidden, and the more recent and acute the case, the more essential is it that absolute rest shall be enjoined. To effect this end in the case of children, Mr. Fisher[1] has devised a "bed-frame" that answers its purpose very well. It consists of two flat iron bars, each with a crutch and strap for the shoulders at one end, and a third or transverse bar that serves to connect the crutch-bars to the head of the bed. The latter bars are also secured to the sides of the bed by bandages. The shoulders being strapped to the frame, and the lower limbs kept still by a weight, any movement of the spine is almost impossible. The American "box-splint" for fractured femur in children answers equally well, if carefully secured to the bed, and steadied also by a weight applied to the lower end of the splint. The duration of the treatment must depend upon the nature of the case and other circumstances, and in the majority of instances is to be estimated by months rather than by weeks. The objections to prolonged recumbency are of course obvious. The treatment is long and irksome, and difficult to carry out efficiently; but Mr. Howard Marsh, and others who advise its practice, have pointed out that the objections raised are somewhat exaggerated, and that the difficulties are by no means insurmountable.[2]

(2) *Mechanical Appliances.*—A vast number of instruments have been invented to meet the various indications for local treatment. The objections to most of these appliances are the following: They are heavy and often irksome, possess but little adaptability, and must be changed or altered as the child increases in age. The expense would forbid their use—even if considered desirable—to any extent in hospitals. For the most part they take their lower point of support from the pelvis; but the pelvis of a child is so small comparatively, that this basis is often delusive, and it is, moreover, unstable. The result is that few of these instruments are of any use, and that a large number do positive harm. The least objectionable form of instrument is that where the lower support is taken from a broad, rigid band, well moulded to the hips and pelvis. The body and spinal column above the seat of disease are supported by crutch bars that pass from this band to the

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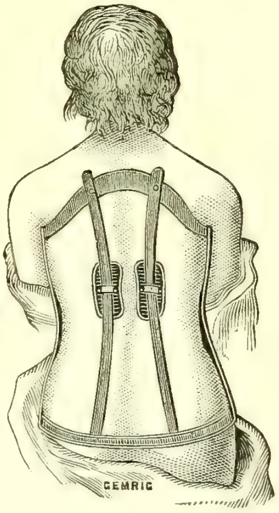
[1] Lancet, Feb. 1878.

[2] Treatment of Spinal Caries in Childhood. British Medical Journal, vol. ii. p. 769. 1881.

axillæ, and that can be lengthened or shortened at pleasure. The best examples, however, are somewhat cumbrous.

[A better form of apparatus than that described by the author is such as is shown in Fig. 812, the principal support being given by iron uprights on either side of the vertebral column. The cut illustrates the spinal brace devised by Dr. C. F. Taylor, of New York, which, with various modifications, is extensively employed in this country.]

Fig. 812.

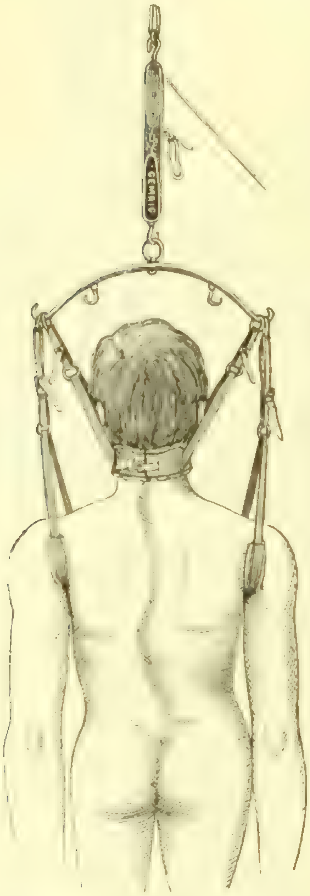


Taylor's apparatus for the treatment of Pott's disease of the spine.

(3) *The use of rigid Jackets with or without Suspension.*—By the introduction of his now well-known "jacket," Professor Sayre has caused almost a revolution in the treatment of Pott's disease of the spine. When first introduced, this plan of treatment was very widely, blindly, and enthusiastically adopted, and was regarded by some as a panacea for all deformities of the back. Since that time a certain reaction has set in, and there are now not a few who condemn the use of Sayre's apparatus as of little use, and as at least inferior to other modes of treatment. As is usual in similar cases, the truth probably lies between these two extremes, and I feel convinced that Sayre's method affords an admirable remedy for Pott's disease, but at the same time a remedy that must be properly and carefully restricted in its use. The details of Sayre's method are too well known to require minute description. The main features are simply these—extension is applied to the spine by means of suspending the body (Fig. 813), and while in the extended posture a rigid jacket of plaster of Paris is applied to the trunk. The body is suspended by means of a collar beneath the chin and occiput, and by bands beneath the axillæ; a tripod stand is used, and the suspending force is directed through a series of compound pulleys. (Fig. 814.) The first point to be discussed in this mode of treatment is the matter of *suspension.* By means of it the diseased surfaces of contiguous vertebræ are drawn asunder, muscular contraction is overcome, and the column is restored—as regards its curvatures—to something more closely approaching the normal. Facts, however, are greatly needed that will throw more light upon the precise effect of suspension upon the diseased part. Fisher suspended the cadaver of a child who had suffered from Pott's malady. The whole of the body of the first lumbar vertebra had been destroyed by disease, and the contiguous vertebræ were eroded. When in the recumbent posture, the diseased parts were in contact, but on suspension they became separated no less than a quarter of an inch.

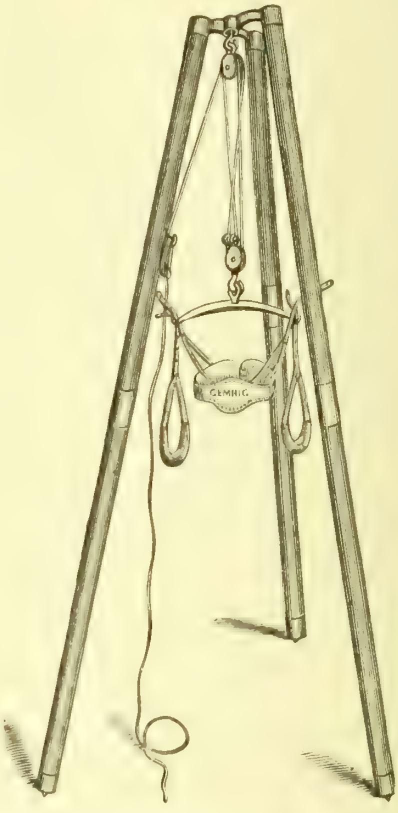
It must be remembered that the extending force is the weight of the body below the seat of disease, and that this force will be the greater as the carious part is higher up. It will also increase with the age of the patient and the development of the lower limbs, and will be much influenced by the extent of disease in the column, the destruction of ligaments, the amount of repair, and the degree of muscular contraction. Sayre has pointed out the increase in the patient's height that is to be observed during suspension in cases of "angular curvature," but it must not be imagined that this increase is due solely to a separation of parts at the seat of disease. Were it so, the advantages of suspension would be very doubtful. He mentions, for example, the case of a man aged 19, with Pott's disease, who gained three-fourths of an inch in height on suspension. The production of a gap of this width in the anterior part of the spinal column would be a very questionable advantage. The increase in height, under such circumstances, is due, to a great extent, to the stretching of the column and unfolding of its natural curves; and it is observed in the normal spine of any individual suspended according to Sayre's method.

Fig. 813.



Suspension of patient for application of rigid jacket by Sayre's method.

Fig. 814.



Tripod for suspending patient in applying rigid jacket.

The object of the *rigid jacket* is to steady the spine, and to retain it, as nearly as possible, in the position which it assumes during extension. It aims at giving physiological rest to the part, it minimizes the effects of shocks and violent movements, and, by preventing mutual pressure and friction of the diseased surfaces, it is presumed that its use will arrest the progress of the malady and favor the process of repair. It is claimed, moreover, for the jacket, that it is inexpensive, readily applied, and composed of materials that can be anywhere obtained; and, lastly, much has been said in favor of its simplicity, its comparative lightness, and the comfort which it affords the patient.

Many objections have, as already mentioned, been made to Sayre's treatment, both as a whole and in its details. The objections to the main principles of the method may now be briefly discussed. It has been urged that suspension pulls asunder the diseased parts, and that, the jacket maintaining them in that position, a cure by anchylosis of the anterior segments of the column is positively prevented. This objection is answered by asserting that the treatment should never be so carried out as to cause an extensive and permanent gap in the column, but that the surfaces should be just prevented from exercising injurious pressure and injurious friction the one upon the other. This exposes the real weakness of the scientific aspect of Sayre's method, for who can tell when the extension is sufficient just to prevent injurious pressure, but not to cause an injurious gap? This question is an important one, and urgently demands an answer. It has been urged, moreover, that the jacket is not capable of supporting the column as maintained by Sayre and others. This objection has especial reference to children, and it is declared that so comparatively slight is a child's pelvis that it affords no proper basis for the support of the column. It is asserted also that the hold which the jacket obtains upon the thorax is not sufficient to support the weight of the body above the seat of disease. In these objections it is assumed that the Sayre's jacket, taking its fixed point from the pelvis, holds up the column in the same manner as would the crutch bar of the steel apparatus for Pott's disease. This is not the case, and the manner in which the rigid jacket supports the spine is more correctly to be compared to the manner in which the four splints around an arm support and maintain position in a fractured humerus.

Some of the details of this treatment may now be considered. In suspending a child, the collar alone is usually sufficient, and by its use very direct traction upon the spine can be obtained. In the cases of elder children and adults, the axillary bands are needed in addition. A collar containing an air pad has been introduced, that renders the extending process less irksome to the patient. As to the amount of the suspension, the rules laid down by Mr. Fisher in his "Essay" are I think the best and the most carefully considered.[1] He details three degrees of suspension. In the *first* degree, the patient is suspended until the toes just touch the ground. He maintains that this should be the extreme degree of extension, and urges that the patient should never be drawn entirely off the floor. He advises this amount of extension for children under 12, with limited destruction of the vertebræ, and for children under 5 in whom more extensive disease exists. In the *second* degree of extension, the patient is drawn up until the heels are raised about two inches from the ground, the "forepads" of the feet being left for the patient's support. This is advisable in more advanced cases of disease, in children under 12, and in severe cases in those under 5. In the *third* degree, the body is raised until the heels are just on the point of being lifted from the ground. This amount of suspension is advised for all cases in adults, or in children over 12, and in severe examples of the disease, between the ages of 12 and 5. Sayre simply advises that the patient be drawn up "until comfortable," and is an advocate for complete suspension. It is certain that patients often experience much relief on suspension, but that fact can hardly afford a proper basis for estimating the amount of force to be used. When the jacket has been applied, the patient must be carefully placed in the recumbent posture while the plaster is still wet, and this practice should meet the objection of those who assert that the jacket may maintain too wide a gap between the diseased parts. In the place of suspension, the jacket may be applied in the recumbent posture, as advised by Dr. Walker, of Peterborough;[1] or during horizontal extension, or extension by an inclined plane. I would most strongly advise the application of the jacket while the patient is in the prone position, extension being maintained by the inclined plane upon which he lies. The prone posture itself tends to lessen the deformity, and to remove the diseased parts from mutual pressure.

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[1] Op. cit., p. 31.

Some few details in the application of the jacket itself may be here mentioned. The vest worn next to the skin must be drawn well down during the application of the plaster bandages, and to effect this end Sayre advises it to be fixed temporarily beneath the perineum. The bandages are made of some loosely-woven material, such as crossbarred muslin, mosquito-netting, or crinoline, and are advised to be about 3 yards long and from 2½ to 3 inches wide. The plaster is to be rubbed into the bandages, which are to be rolled up and then dipped into a basin of water before use. As the plaster so soon spoils, it is well for the bandages to be prepared on the spot for each case as required. During the application of the bandages, an assistant should, with a moist sponge, keep the plaster smooth, and may add, with his hands, a little dry plaster here and there where required. Sayre advises the use of longitudinal strips of tin, that are to be included in the folds of the bandage. They certainly add to the rigidity of the jacket without greatly increasing its weight. Little pads of cotton-wool are to be placed over the iliac spines and any other bony prominences. In the case of females, a pad should be placed over the breasts, to be removed when the jacket is rigid. The "dinner-pad" must not be omitted. This consists of a wedge-shaped pad, inserted beneath the vest over the lower part of the abdomen, with the thin edge of the wedge downwards. It is removed when the jacket is dry, and leaves a potential space between the jacket and the skin. When a discharging abscess exists in a part that would be covered by the jacket, Sayre advises an opening to be made in the following manner: "A piece of oil-silk having been placed over the sinus, a hole should then be cut in the shirt, in order to indicate the size of an opening to be subsequently made in the plaster jacket; and in this hole should be set a folded piece of pasteboard of the same size, and carrying a long sharp pin thrust through its outermost leaf. Now, each turn of the bandage can be carried over the pin without forcing it into the abscess cavity below, and the surgeon is furnished with a guide in making an opening that will lead directly to the diseased surface. When the plaster has nearly set, the bandage should be cut away around the pin until the pasteboard is reached, and an opening made of sufficient size to allow of its easy removal. The oil-silk, which is then exposed, should be starred, or cut into strips from the centre, so that when the strips are reversed they will cover the edges of the opening in the plaster, where they can be glued down with gum-shellac."[2]

When once applied, the jacket may be kept on for one, two, or three months, or until it becomes so weakened as to be useless. In some of Sayre's cases the jacket was kept on for periods varying from seven to twelve months. This practice is to be condemned upon the grounds of the simplest hygiene, and I think that in no case should the same jacket remain on the patient for a longer period than twelve weeks. The difficulty as to cleanliness, in cases where jackets are long retained, is, to some extent, met by the ingenious plan of drawing the old undershirt off while a new one is drawn on without disturbing the plaster jacket. This is effected by attaching the new shirt to the lower border of the old, when, as the old vest is drawn up over the head and removed, the new garment is made to occupy its place.

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[1] See British Medical Journal, Dec. 1878. For an account of Mr. Willett's method of suspension in the prone posture, see St. Bartholomew's Hospital Reports, vol. xiv.

[2] Spinal Disease and Spinal Curvature, p. 19. London, 1877.

The jacket, as already noted, must not be used in early or acute cases; and it is, of course, useless when good consolidation of the part has ensued. It is inadmissible, also, in many cases where lung or heart complications exist, and in instances where an abscess projects in any part that would be covered by the jacket. The treatment also would appear, for many reasons, to be inadvisable in quite young children, although Mr. Golding Bird has applied Sayre's jacket with success to an infant under twelve months of age.[1] There are many objections to the use of plaster of Paris for the rigid casing. The plaster is apt to rub out of the bandages; it can rarely be applied so evenly as to exercise everywhere even pressure and support; it is heavy;[2] and, lastly, it keeps the part from view for a long time, and often prevents serious complications from being detected. An abscess, that was not suspected when the jacket was applied, has shown itself for the first time by an escape of pus beneath the casing, and extensive excoriations also have occurred that might obviously have been prevented had not the jacket been immovable. Many of these objections are met by the use of the poro-plastic jacket. These jackets are made from a prepared felt, and are moulded upon a block so as to form corsets of various sizes suitable to patients of all ages. The patient is suspended in the usual way, and, wet clothes having been wrapped about the body, a corset of proper size is moulded to the figure. This moulding is readily effected, inasmuch as the jacket is rendered very pliable by a momentary immersion in boiling water. It is to avoid the injurious contact of the heated jacket that wet clothes are applied to the body during the moulding process. The felt soon "sets" again. The corset having been properly shaped, is then laced down the front, and, although it forms a perfectly rigid casing for the body, can yet be removed as often as is needed, and as readily reapplied. It has the further advantages over plaster of Paris, of being much lighter, firmer, and more equable in its support, and of requiring a shorter period of suspension.

Agnew describes a jacket of half-tanned leather, which is thus applied: The child is suspended, and a Sayre's jacket applied in the usual way. The patient is kept suspended until the plaster is dry, and the jacket is then cut down in the middle line in front, and removed. From this jacket a cast in plaster of Paris is taken, and upon this the leather corset is moulded. The corset is strengthened by longitudinal strips of steel, and, when applied, is laced down the front. I fail to see the advantage of this apparatus over the simple poro-plastic jacket. Its use involves much trouble and labor, and great inconveniences to the patient, not the least of which is the prolonged suspension.

The treatment of Pott's disease varies according to its situation. When the caries is in a part of the spine below the third or fourth dorsal vertebra, a jacket of some kind applied in the suspended posture may be used in the manner already detailed. But when the disease is at or above the third dorsal vertebra, suspension is no longer of use, and the jacket alone would be also of no avail. In such cases the head must be fixed, and the upper part of the column kept rigid and extended by some form of "jury-mast." (Fig. 815.) This jury-mast consists essentially of a rigid bar of malleable iron or steel, that is placed along the back (being moulded to its curve), and extends some way above the head. To the summit of the bar an apparatus is fixed, that keeps the head extended and the affected spine at rest. In Sayre's "jury-mast," the head is, as it were, suspended by the apparatus: extension is kept up, but rotary movements of the head are permitted, as is also some lateral motion. A better apparatus is that advocated by Fisher, which differs from Sayre's instrument in so far that it not only maintains the extended position, but at the same time prevents, by its rigidity, all movements of the head and cervical spine. In any case, the vertical bar is fixed below, either to a Sayre's plaster jacket applied in the usual way, or to a poro-plastic corset. In the former case it is retained by being included in the folds of the plaster bandages, and in the latter it is fixed to the corset by means of rivets. In either case the necessary firmness needed for the support of the bar is given by several transverse pieces of metal attached to the lower part. There can be little doubt but that the latter method of fixing the jury-mast is infinitely the more advantageous. In these cases of disease above the third or fourth dorsal vertebra, recumbency is almost imperative as a preliminary measure, and should be insisted on as long as the mischief is acute and progressing actively.

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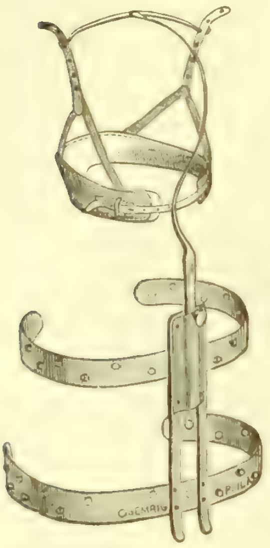
[1] Trans. Internat. Med. Congress, 1881, vol. iv. p. 161.

[2] The jacket, as applied to quite young children, may weigh five or six pounds. (Trans. Internat. Med. Congress, vol. iv. p. 168.)

Fig. 815.



Jury-mast, for support of head in cases of Pott's disease above the third dorsal vertebra.

The *general treatment* of the malady needs little detail. The patient's health must be attended to: change of air, especially to the seaside, is to be advised, and a liberal diet should be ordered in all cases where such a diet is obtainable. If the state of the digestive organs does not forbid its use, cod-liver oil should be given throughout the whole course of the disease, especially when the patient is a child and scrofulous. Among other drugs, iron, iodine, phosphorus, and quinine are of service, and one of the most suitable drugs for children is, perhaps, the compound syrup of the phosphate of iron.

The treatment of the *abscess* is a subject of much difference of opinion, and on this matter the reader is referred to the article on Abscesses in a previous volume.[1] As far as my own experience goes, I should advise an evacuation of the matter by the aspirator at as early a period as possible, and I do not think that facts support the practice of temporizing, with the hope—which is always very meagre—that the pus will be absorbed. When the collection re-forms after the puncture, it may be again aspirated, and this procedure may be repeated a great many times. After each operation, the skin about the puncture should be kept for a while painted with collodion, and in any case every care should be taken to protect the parts from friction and injurious pressure.

In the majority of cases, the skin at the most prominent point of the abscess will become greatly thinned, and possibly inflamed, and the condition will be such that the collection, if left any longer, will discharge itself through the integuments. In anticipation of this, a free opening should be made into the abscess under antiseptic precautions, and the wound should be dressed antiseptically until such time as antiseptic measures are considered unnecessary or unadvisable. At each dressing, it is well that the abscess-cavity should be gently syringed with a weak carbolic solution (1 to 100 parts).

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[1] See Vol. II., page 268.

If the opening be in the loins or back, or in any part that would be covered or interfered with by any jacket or mechanical apparatus, then should such appliances be discontinued, and the recumbent position be insisted on. When the discharge has diminished, a jacket may be applied with a hole in such part of it as corresponds to the sinus. This aperture may still be dressed antiseptically, and the patient allowed to get up.

Disease of the Atlo-axoid Region.

Diseases of the bones and joints in this region, although they differ in no way pathologically from like diseases in other parts of the column, are yet conveniently considered apart on account of the distinctive clinical features which they present. The special features of disease in this part depend upon the peculiar structure and outline of the bones themselves as compared with the other vertebræ, upon the peculiarity of the joints between them, the free and elaborate movements in those joints, and the very close proximity of that most important part of the cerebro-spinal system, the medulla oblongata.

Pathological Anatomy.—The parts concerned in this region are the atlas, the axis, and the condyles of the occipital bone, together with the atlo-axoid and occipito-atloid joints. The disease in these parts may assume very variable aspects. As a rule, it consists essentially of an arthritis of one or other of the joints just named. This arthritis is nearly always associated with gross bone-mischief, and may be attended with very extensive necrosis or caries, of either the atlas or the axis, or both. There are cases where a caries or a necrosis of these bones has appeared to exist independently of any joint-mischief, and that such a condition may occur, is a matter beyond doubt. But such cases are not common. Such is the arrangement of the articulations in this region that external bone-disease is scarcely possible independent of joint-mischief, and in any case where a fairly extensive necrosis or caries exists, it may be safely concluded that some one or other of the neighboring articulations is involved. In any case the mischief most usually commences in the joint, but it may commence in the bone, and this especially applies to cases where the anterior portions of the atlas or axis are carious or necrosed.

There is nothing peculiar about the bone-affection or joint-affection as it appears in this region. The caries and the necrosis are of the same nature and disposition as caries and necrosis elsewhere. The joint-malady usually assumes the form known elsewhere as "white swelling." It is nearly always chronic, is apt to lead to "pulpy degeneration" of the soft parts involved, is prone to induce extensive mischief in the cartilages and bones, and is usually associated with suppuration. Deformity of the affected joint from partial dislocation is common, as is also extension of the suppuration and the formation of sinuses; and lastly, the malady may end in a more or less complete anchylosis. Indeed, in all their features—not excluding their etiology—a large number of the joint-affections in this part are identical in their general pathological features with the white swellings or strumous joint-diseases of other regions.

Sometimes the disease in this segment of the column may follow upon injury alone, and then the pathology of the articular or osseous changes is identical with that of like changes elsewhere that depend upon a like cause. The same remark applies to those instances of atlo-axoid disease that are considered to be due to syphilis; of the two joints mentioned, the atlo-axoid articulation would appear to be more frequently involved than that between the atlas and occiput, but on this point there are some differences of opinion.

In diseases of the atlo-axoid joint, some displacement of the bones is very common, and indeed usual. This takes the form of a sliding forward of the atlas upon the axis. It may be presumed that this displacement is permitted by a softening of the ligaments around, and especially of the transverse and odontoid ligaments. The odontoid process thus encroaches upon the spinal canal, and the most serious results of this disease are apt to follow therefrom. The atlas may slide symmetrically forwards, but more usually the displacement is more or less unilateral, one lateral mass of the atlas being in advance of the other. The displacement is usually very slow in its occurrence, and any sudden displacement in this direction causes instantaneous death. It follows from the deformity that a very sharp bend is given to the cord opposite the seat of mischief, and it is a matter of much interest to note to what extent the spinal canal may be encroached upon without a fatal result ensuing therefrom. Thus, Sir James Paget has recorded an instance of disease in this region, where the atlas, and with it the occiput, had slid so far forward on the axis that the spinal canal was more than bisected by the posterior arch of the atlas. The odontoid process had remained with the axis. The bones were greatly anchylosed in this position, so that the condition must have existed long enough for this tardy mode of cure to be effected.[1] In some cases the odontoid process may become separated from the body of the axis, and, adhering to the atlas, may be carried forward with that bone when it is displaced.[2]

Dislocations at the occipito-atloid joint from disease are very rare. According to Follin and Duplay, they may be bilateral or unilateral, and consist, as a rule, of a displacement of the occipital bone backwards. In only one recorded instance was this bone displaced forwards.[3]

When caries and necrosis exist in this part, they usually involve the anterior portions of the bones, the parts most commonly implicated being the anterior arch of the atlas, the body of the axis, and the odontoid process. The anterior arch of the atlas and the odontoid process have separated almost entire, as sequestra, and considerable portions of the body of the second vertebra have been lost in like manner. Or these parts may either alone or conjointly be more or less carious,[4] and in one case, to be again alluded to, no trace of the odontoid process was to be found after death.

In some cases where the joints are the parts mainly involved, the process may run its course and end in cure without any abscess appearing, although some evidences of suppuration are usual. The suppurative process set up by the disease, no matter whether primarily in joint or in bone, tends to invade the adjacent soft parts, and the abscess formed may present at the sides, or at the back of the neck. Having reached the connective-tissue layers of the neck, the abscess may extend in a downward direction and appear in a distant part. Thus, Smith, of Dublin, records a case in which an abscess proceeding from occipito-atloid disease presented itself in the supra-clavicular fossa, and ultimately opened into the lung. Bryant describes a case in which the abscess formed behind the sterno-mastoid muscle, and in which from the opening in the skin that was formed, a piece of the lamina of a vertebra was discharged.[5]

Very commonly, the abscess presents itself in the tissue behind the pharynx (retro-pharyngeal abscess), and this is especially the case in instances of bone-disease in the anterior parts of the upper cervical vertebræ. This retro-pharyngeal abscess may burrow down behind the pharynx and reach even to the mediastinum. In other cases the pus may go towards the spinal canal, and may form a collection between the dura mater and the bone: or having pierced that membrane it may enter the arachnoid space, and lead to a rapidly fatal result. Follin and Duplay assert that the vertebral artery may be opened by the suppurative process, and such a hemorrhage take place into the spinal canal as to lead to compression of the cord. As in Pott's disease, the mischief may progress to a fatal issue without remission, or a cure may follow without any previous evidence of abscess, or a like good result may follow after the abscess has appeared, and that too after it has discharged itself through the skin.

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[1] Med.-Chir. Trans., vol. xxxi. p. 286, 1848.

[2] Shaw, Holmes's System of Surgery, 2d ed., vol. iv. p. 140.

[3] Traité élémentaire de Path. Ext., tome iii. p. 73, 1868.

[4] See case by Dr. Ogle, where the atlas, the axis, the occipital condyles, and the edge of the foramen magnum were all carious. Trans. Path. Soc., vol. xv. p. 19.

[5] Manual for the Practice of Surgery, 2d ed., vol. i. page 278.

In cases where anchylosis has taken place, the outlines of the bones involved may be very confused, and the deformity remarkable. In a case noted by Sir Wm. Lawrence, the atlas, axis, and occipital condyles were fused together in one firm mass. The bones had been partially dislocated from one another, and the odontoid process was thrust so far into the foramen magnum as to really occupy the cranial cavity.[1] In a specimen described by Dr. Lochee and Mr. C. H. Moore, the four upper cervical vertebræ and the occipital condyles were fused together. The bones were all much compressed and distorted, and their outlines very confused. There was no trace of the odontoid process. The bodies of the two upper cervical vertebræ had invaded the foramen magnum, and were practically in the cranial cavity. The spinal canal, at the seat of disease, was, as may be imagined, much diminished in capacity.[2] Lastly, it is to be noted that the spinal cord may be compressed or crushed by fragments of bone separated in the progress of the disease.

Etiology.—The etiology of disease in this region is very similar to that of Pott's malady. The disease occurs mostly in childhood and youth, and is ascribed in the bulk of instances to the influence of scrofula. It is rare in those of mature age, and very rare in the old. The mischief may also follow after injury, and this would seem to be one of its most frequent causes in those cases that appear late in life.[3] Cold, unwonted use of the part—as in carrying weights upon the head, etc.—rheumatism, gout, etc., have been somewhat vaguely regarded as active causes in producing disease of the upper cervical spine. Syphilis would appear to be a frequent cause of the disease, and especially of that form of it that principally attacks the bone. There are several recorded cases where disease of the upper vertebræ has followed upon deep ulcer of the pharynx, and it is very probable that all these examples have been due to syphilis.

Symptoms.—The symptoms of spinal disease in this region may be conveniently arranged under the heads, (1) Pain, (2) A certain rigidity of the neck, (3) Swelling, (4) Deformity, (5) Signs of abscess, and (6) Evidence of pressure upon the cord.

(1) *Pain* is very often one of the first signs of the malady under consideration. This pain is mostly complained of along the course of one or more of the following nerves: the great occipital, the small occipital, the great auricular, the superficialis colli, and the descending branches of the cervical plexus, viz., the sternal, clavicular, and acromial nerves. It is necessary to remember that the first cervical nerve escapes between the occiput and the atlas, the second between the atlas and the axis, and the third beneath the latter bone. So

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[1] Med.-Chir. Trans., vol. xiii. 1827.

[2] Lancet, vol. vii. 1867, p. 637.

[3] See example of occipito-atloid disease, ending in anchylosis, in a man aged sixty-four. It followed upon a fall on the head. There was no fracture. Med.-Chir. Trans., vol. xxiv. 1841.

that in disease of this region of the column, the first three cervical nerves may readily be implicated, and, as the branches above named are all sensory nerves, the distribution of the pain may be very definite. The two occipital nerves are branches of the second cervical; the great auricular and superficialis colli, of the second and third cervical; and the descending nerves, of the third and fourth cervical. Thus the two occipital nerves are the two most likely to be irritated, together with those parts of the great auricular and superficialis colli that are formed by the second cervical. The third nerve can only be implicated when the disease extends to the lower part of the axis. The distribution of pain, therefore, may be of some value in localizing the mischief. As the upper cervical nerves lie close to the bone where they issue from the spinal canal, it can well be imagined that they are early and readily affected by any inflammatory changes in those bones. Thus, then, among the first signs of disease in this region is pain about the back of the head and upper part of the neck, or about the sides of the neck and sometimes in the ear, or less frequently about the shoulders and upper part of the chest. The pain varies in intensity in different cases, is commonly neuralgic in character, and often very severe. It is made worse by any pressure upon the head that brings the occipital condyles forcibly on to the spine, and by movements that concern the joints of the first two cervical vertebræ. It is often increased also by any sudden movement or any jolting of the column. Hilton says that the pain in disease of the lower cervical, the dorsal, and the lumbar spine, is "almost always symmetrical," but that in disease involving the first two joints of the column it is unilateral: and that this feature serves to point out which side of the vertebræ is involved.[1]

(2) In all cases, a certain amount of *stiffness in the neck* becomes apparent, and is among the earliest and the most striking symptoms of the disease. The movements that are limited will depend to some extent upon the parts involved. If the occipito-atloid joint be alone implicated, all nodding movements of the head will be arrested, while some rotation of the head will still be possible. If, however, the disease involve only the atlo-axoid articulation, then will all rotary movements be checked, while the nodding motion may still be effected. As a matter of fact, however, both of these movements are usually more or less arrested in disease of this region, no matter how limited it may be. The parts are so intimately related that movement of one joint can hardly fail to disturb the other joint, and while nodding movements may possibly be effected without great discomfort in atlo-axoid disease, it is very improbable that rotary movements could be made with a like ease should the malady attack the upper of the two articulations. In most cases, the greater part of the whole of the cervical spine is rigid. If the patient be asked to turn his head, he effects the movement by rotation of the dorso-lumbar spine, or by turning of the entire body; and any nodding movement of the head he replaces by a bending or bowing movement of the trunk.

(3) *Swelling* about the nape of the neck soon becomes obvious, and this may be such as to obliterate the suboccipital fossa. It varies greatly in amount in different cases. The swelling may involve some part of the side of the neck, appearing very deeply seated, or it may occur in the post-pharyngeal region. In the latter region it may cause early dysphagia. The more superficial swelling may be associated with some tenderness, and, in thin subjects and in acute cases, with some decided increase in the temperature of the skin.

(4) After the disease has existed for a variable period, some *deformity* usually becomes obvious. Before this, however, takes place, the patient will

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[1] Lectures on Rest and Pain, third ed., 1880, page 92.

possibly have adopted a carriage more or less typical of lesion in the region of the column now under notice. The head may be kept bent forwards, or backwards, or to one side, or in the position of rotation; the first mentioned position is the most common. Sometimes the patient may appear to be unable to support the head by means of the usual muscles; he prefers the recumbent posture, with his head sunken in a pillow, and, if required to get up, will support his head with his hands. The actual deformity as a rule depends upon the sliding forwards of the atlas upon the bone beneath. When this occurs, the chin and face are advanced, and are stifly poked forwards. The roundness of the upper part of the back of the neck is lost. The spine of the axis becomes prominent, and may be readily felt or seen. This deformity when present is very characteristic, and is well represented by Mr. Shaw in a drawing in his monograph already referred to. The displacement, when in any way well marked, may be sometimes felt by examination of the part through the upper and posterior part of the pharynx.

(5) The disease may run its entire course, and end in cure, without any *abscess* appearing externally. As a rule, however, abscess does appear, although that appearance may be long delayed. The purulent collection may present itself at the back or side of the neck. In the latter position it will be deep-seated, and may cause severe symptoms and great difficulty in diagnosis. Such an abscess will, however, have—apart from the spinal disease—no especial characters that separate it from other deeply-seated cervical abscesses. In some cases (and in those particularly that depend upon necrosis of the anterior parts of either of the two upper vertebræ) the purulent collection may appear as a "post-pharyngeal abscess." An abscess in this situation may cause very obscure and very severe symptoms. In a case already associated with evidences of disease in the upper cervical region, a swelling appears behind the pharynx, that may in time increase so as to push forward the soft palate, or may extend so low down as to be obvious from the mouth. This swelling is associated with much pain and distress, with considerable difficulty in deglutition, and often with alarming dyspnœa. The cause of this dyspnœa has in more than one recorded case been overlooked, and tracheotomy proposed or practised for its relief. Very often the abscess presents itself at the same time at the side of the neck. Thus, Mr. Hilton[1] records a case of a child, aged twelve months, who in addition to the post-pharyngeal swelling had an abscess that extended to the angle of the jaw, pushing forwards the trachea and carotid vessels, and lifting up the sterno-mastoid muscle. The collection was opened in the neck, and the pharyngeal tumor at once subsided. Sir James Paget[2] gives an instance where the post-pharyngeal abscess was complicated by an extension of suppuration to the parotid region, associated with rigidity of the jaw. The collection opened spontaneously through the pharynx, and a severe hemorrhage followed. The hemorrhage recurred and proved fatal. The autopsy showed caries of the anterior arch of the atlas, and an abscess-cavity about the carotids, and between the tonsil and the parotid gland. The source of the bleeding was not discovered. The post-pharyngeal abscess may open into the pharynx, or may discharge itself through the integuments of the neck, but an opening in the former situation is the more common. The bursting of the abscess into the pharynx may cause death by asphyxia, the matter finding its way into the larynx. Or, independent of its bursting, the collection may cause death by asphyxia, that end being brought about by pressure.

Several cases are recorded where the mischief in the bones has been secondary to an ulcer of the pharynx, and in all these instances the disease would appear to have been due to tertiary syphilis. The following was a case of this kind:[1] The patient, a man aged 35, had an extensive syphilitic ulcer of the pharynx, that had destroyed the soft palate and exposed the anterior arch of the atlas. This process of bone necrosed *en masse.* Other instances of pharyngeal ulcer associated with bone-disease in the cervical spine are evidently secondary to the osseous lesion, and due to extension forwards of the destructive process. Through these ulcers, or through the abscesses after evacuation of their contents, sequestra have been discharged or removed by operation. Thus, in the case just mentioned, the whole of the anterior arch of the atlas was removed through the pharynx as a sequestrum. Mr. Keate[2] has given an account of a like operation. Mr. Bryant[3] records the case of a woman who coughed up, as a sequestrum, the odontoid process, and who, nevertheless, made a good recovery. The same surgeon has also seen "the anterior half of the atlas, with its articular facets," expectorated, and a cure follow its elimination. Mr. Hilton also details the case of a patient who coughed up the anterior arch of the atlas, the sequestrum haying escaped by way of a pharyngeal ulcer.[4]

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[1] Op. cit., page 135.

[2] Holmes's System of Surgery, 2d ed., vol. i. p. 133.

(6) The symptoms that depend upon *implication of the cord and the upper spinal nerves* are very varied. Some of these symptoms have already been alluded to in dealing with the matter of *pain*, and I now propose to consider some of the graver evidences of this complication. The period at which these symptoms make their appearance is very uncertain. The disease may run its entire course, and end in cure, without cord-symptoms of any kind having been observed; or, on the other hand, such symptoms may be among the earliest evidences of the malady. The first evidences of these nerve-complications may be very trifling and obscure, while in not a few cases the first and only sign of injury to the cord has been sudden death. Such instances of sudden death are, probably in all examples, due to a giving way of the transverse and odontoid ligaments, whereby the atlas, bearing the entire weight of the head, slides forward upon the axis, and thus crushes the lower part of the medulla. In most instances, however, the symptoms develop very slowly, and proceed from bad to worse in progressive cases. There may at first be tingling or darting pains in one or other of the limbs, usually in the upper extremities. This may be followed by a feebleness that may pass on to more or less complete paralysis. Some few cases are recorded where pain and weakness have appeared in both arms and in both legs at once. The paralytic symptoms may be preceded by spasmodic contractions of various muscles, and by convulsive movements of the limbs. In the case recorded by Dr. Lochee and Mr. C. H. Moore, and quoted above, the fingers and wrists were contracted in the flexed position, and a like continuous spasm was noted in the feet; there was muscular weakness, but no paralysis. In a case seen by Mr. Shaw, "the muscles became affected with tonic spasm; the whole body was so rigid that on turning the patient in bed she rolled with the stiffness of a corpse having rigor mortis; that condition lasted for a month; it gave place gradually to ordinary paralysis, from which she eventually recovered."[5] The paralysis may vary greatly in extent; it is apt to be general rather than local, and although some patients become paraplegic merely, and others exhibit no more extensive paralysis than loss of power in one arm, yet the bulk who show motor defects show those defects over an extensive series of muscles, and exhibit a condition that varies from general muscular weakness to general paralysis of parts below the neck. Sensation is much less frequently impaired than motion, and would appear to be scarcely ever im-

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[1] Med.-Chirurg. Trans., vol. xxxii. p. 64. 1849.

[2] Medical Gazette, vol. xii. 1835.

[3] Op. cit., vol. i. p. 281.

[4] Op. cit., p. 113.

[5] Loc. cit., p. 145.

paired without motor defects; but with extensive paralysis there may be considerable anæsthesia. In the cases of wide-spread paralysis, there is usually loss of control over the bladder and rectum.

A fatal termination may be preceded by certain cerebral symptoms—vertigo, headache, vomiting, convulsions, and epileptiform attacks; or death may be sudden, from a sudden crushing of the cord in the manner above detailed.

In addition to these particular symptoms, the patient with disease of the upper cervical spine may exhibit certain general symptoms—such as fever, marasmus, hectic, fatty and amyloid degeneration of viscera from long-continued suppuration, etc.

Differential Diagnosis.—In the diagnosis of disease in the occipito-atloid and atlo-axoid regions, the following sources of fallacy must be eliminated: *Muscular rheumatism* in the cervical region may cause stiffness of the neck, with pain on movement, and has been mistaken for the graver malady. The spinal disease, however, is most common in the young, at an age when this form of rheumatism is quite uncommon. The rheumatic affection is associated with a good deal of tenderness on pressure, a symptom absent or but slightly marked in the spinal ailment. Steady pressure of the head vertically down upon the vertebral column will not increase the pain in muscular rheumatism; nor is that pain as much aggravated by jolts and sudden movements as it is in the spinal affection. The neck, in severe muscular rheumatism, will be quite stiff, but in the more deeply seated disease, rotation of the head may remain comparatively free, while nodding is impossible, and *vice versa*. The rheumatic affection is associated with no deformity, such as projection of the spine of the axis. It may be attended with pains in the limbs, but these can easily be differentiated from the nerve-pains in the spinal disease. The progress of the case and the effects of treatment will readily remove in time any difficulties in diagnosis.

A deep-seated cervical abscess, associated with rigidity of the neck, pain on movement, etc., may cause error in diagnosis, and the source of the abscess may be wrongly imputed. The simple cervical abscess does not tend to cause rigidity of the neck until it is well advanced, whereas the abscess due to spinal disease will have been preceded by rigidity of the parts for perhaps a considerable time. In the simple abscess, the neck is apt to be drawn to one side, a position uncommon in the spinal affection. In the simple abscess the pain is not apt to be increased by carefully applied pressure to the vertex; there will be an absence of spinal deformity, of post-pharyngeal mischief, and of cord and nerve symptoms. Lastly, the source of the non-spinal abscess may be made out, and a positive diagnosis be thus established. *Torticollis*, *phlegmon of the neck*, and *glandular disease* are enumerated by some authors as affording possible sources of fallacy in diagnosis; but the points of resemblance between these affections and the spinal malady are not sufficiently close to merit further notice.

Prognosis.—The progress of the disease varies considerably both as to the manner and the rapidity of its advance. Within a short time from the commencement of the disease, the patient may be bedridden; and, on the other hand, cases are met with like one recorded by Shaw, where a patient, a servant-girl, continued her work without inconvenience until the deformity, due to the sliding forwards of the atlas on the axis, was well marked. On the whole, the prognosis in this malady is grave, the seriousness of a case depending mainly upon the implication of the cord. Although the majority of the deaths from this disease are due to nerve-complications, a fatal result may be brought about in other ways. Thus, the patient has sometimes died from asphyxia, owing to an inability to cough or expectorate. The escape of pus into the larynx from a post-pharyngeal abscess has caused death by a like means. The rigidly retained recumbent posture has led to fatal hypostatic congestion of the lungs; and other patients have died of marasmus, or of some of the evils that attend upon suppuration and discharging sinuses. The least serious form of paralysis is that which involves the upper extremity, especially when it implicates but one limb, or but a part of one; the most grave form appears as equal paralysis of both lower extremities, or of the entire body. It is well, however, to remember that even the most severe forms of paralysis may be recovered from in this malady. Thus Shaw cites the case of a man aged 48, with disease of the atlo-axoid articulation, who was, for six months, entirely paralyzed "from the head to the toes," and who, nevertheless, made a perfect recovery. It is obvious that age influences the prognosis considerably, and that the younger the patient the more probable is a good result, other things being equal.

As the cure is by anchylosis, any deformity that has developed must persist, as must also a considerable defect in the range of movement. Cases have, however, been recorded here and there, where a good deal of movement has been recovered after extensive disease that has involved the bones rather than the joints. Thus, in a case where nearly the entire anterior arch of the atlas came away as a sequestrum, the patient recovered with the rotatory movements of the head "almost perfect," and with but incomplete limitation of the nodding movements.[1]

TREATMENT.—The general treatment of these cases of spinal disease needs no comment. The local treatment should be such as to insure absolute rest to the part, and to prevent displacement of the bones. These ends can only be properly secured by a rigidly maintained recumbent posture. The patient should be placed absolutely flat upon his back, upon a firm and level mattress. Beneath the nape of the neck, a small, firm cushion should be placed; and the occiput may rest either upon a very slight, soft pillow, or upon a circular pad, so hollowed in the centre as to relieve the more prominent part of the occiput from any injurious pressure. The importance of the small, hard cushion beneath the nape of the neck—as first advised by Mr. Hilton—cannot be over-estimated. Without such a support, the recumbent position becomes almost useless. Mr. Hilton has shown by a reference to anatomical facts, and by experiment upon the dead body, that this little cushion supports the axis and tends to lift it up. By this means the gliding forward of the atlas upon this bone is rendered impossible, compression of the cord is thus avoided, and the slight flexure given to the spine acts by way of slight extension upon the diseased parts. The head should be kept fixed in the position indicated, by two large sand-bags, placed one on either side of the head and neck. In cases where the patient is restless and apt to move the head, immobility may be secured by a linen cap that comes well forward on to the forehead, and is secured under the chin and around the neck. To the front of this cap, linen bands are attached transversely, and secured to the sand-bags. By these means the head may be kept secured to the bed, and none but the most trifling movement permitted. This position should be maintained strictly for as many months as may be required. From three to six months will be sufficient in the bulk of cases. The recumbent posture rigidly maintained in the manner just indicated, is the only safe position for a patient with active disease about the atlo-axoid region. Hilton records the case of a little girl, aged 5, who presented very severe symptoms in connection with this spinal disease. The recumbent posture was ordered and maintained most rigidly. In 14 days the child had remarkably improved, when an officious nurse, in direct disobedience to orders, thought fit to ask the child to sit up. The child did so; the head fell forwards, and the patient was dead.[1] The relief that the recumbent posture often gives to some of the most urgent symptoms of the malady is well shown in the following case, also recorded by Mr. Hilton. The patient—a young woman—when seen by Mr. Hilton, was almost pulseless, was unable to swallow, was scarcely breathing, and not quite conscious, and was paralyzed nearly completely in both arms and legs. She was propped up in bed by pillows at her back, with her head inclined somewhat forwards. Her death appeared imminent. She was at once laid flat upon the bed, with a pillow beneath the nape of her neck, as above described. The sense of suffocation was immediately relieved, and the severity of the other symptoms soon diminished. She retained the recumbent posture for six months, and then left the hospital cured.

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[1] Med.-Chir. Trans., vol. xxxii. page 64.

When it is believed that firm consolidation has taken place, the patient may be allowed to get up; but before such a change in position is permitted, the head and neck must be fixed in some rigid apparatus. This apparatus may consist of a well-moulded stock of gutta percha, leather, or poro-plastic felt, and should be well secured below to the shoulders, back, and chest, and above to the chin, lower jaw, and occiput. Or, in the place of these appliances, a jacket may be fitted to the trunk, and a jury-mast applied in the manner indicated when dealing with the treatment of Pott's disease. The diseased parts should be thus maintained until perfect cure has resulted. In no case should any of these instruments be used as a preliminary mode of treatment, to the disregard of the recumbent position. In all cases they should be merely supplemental or secondary to the treatment by posture. Those who deprecate prolonged recumbency urge that many cases do well and end in cure when this measure has not been made use of. But it must be remembered that cases of cure under these circumstances are exceptional, and they should be regarded merely as fortunate occurrences, and not as furnishing grounds for the selection of a mode of treatment. It is, perhaps, needless to observe that attempts to reduce the dislocation, such as have been practised by some surgeons, are quite unjustifiable, and are more likely to end in death than in any improvement.

With regard to the abscess, it should be opened at the earliest opportunity, and a free vent given to the pus. This especially applies to post-pharyngeal collections. These abscesses should be opened by a small puncture that may be subsequently enlarged, and the operation should be performed while the patient is in the recumbent posture, in order that the escaping pus may run down into the gullet, rather than into the larynx, as might readily occur, especially when the subject of the operation is a child. When the purulent collection presents itself both at the side of the neck and behind the pharynx, it may be well to open it in the former situation, according to the method advocated by Hilton.[2] This surgeon has given an example of the opening of an abscess in the neck that presented itself also behind the pharynx. A good result followed. Any sequestra that may be exposed by the opening of the pharyngeal abscess, or by the extension of a pharyngeal ulcer, may be removed by forceps, provided that they are quite loose. Large portions of both the atlas and the axis have been removed through the mouth under these circumstances. In cases due to syphilis, a specific treatment must of course be adopted.

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[1] Op. cit., page 111.

[2] See Vol. II. page 269.

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